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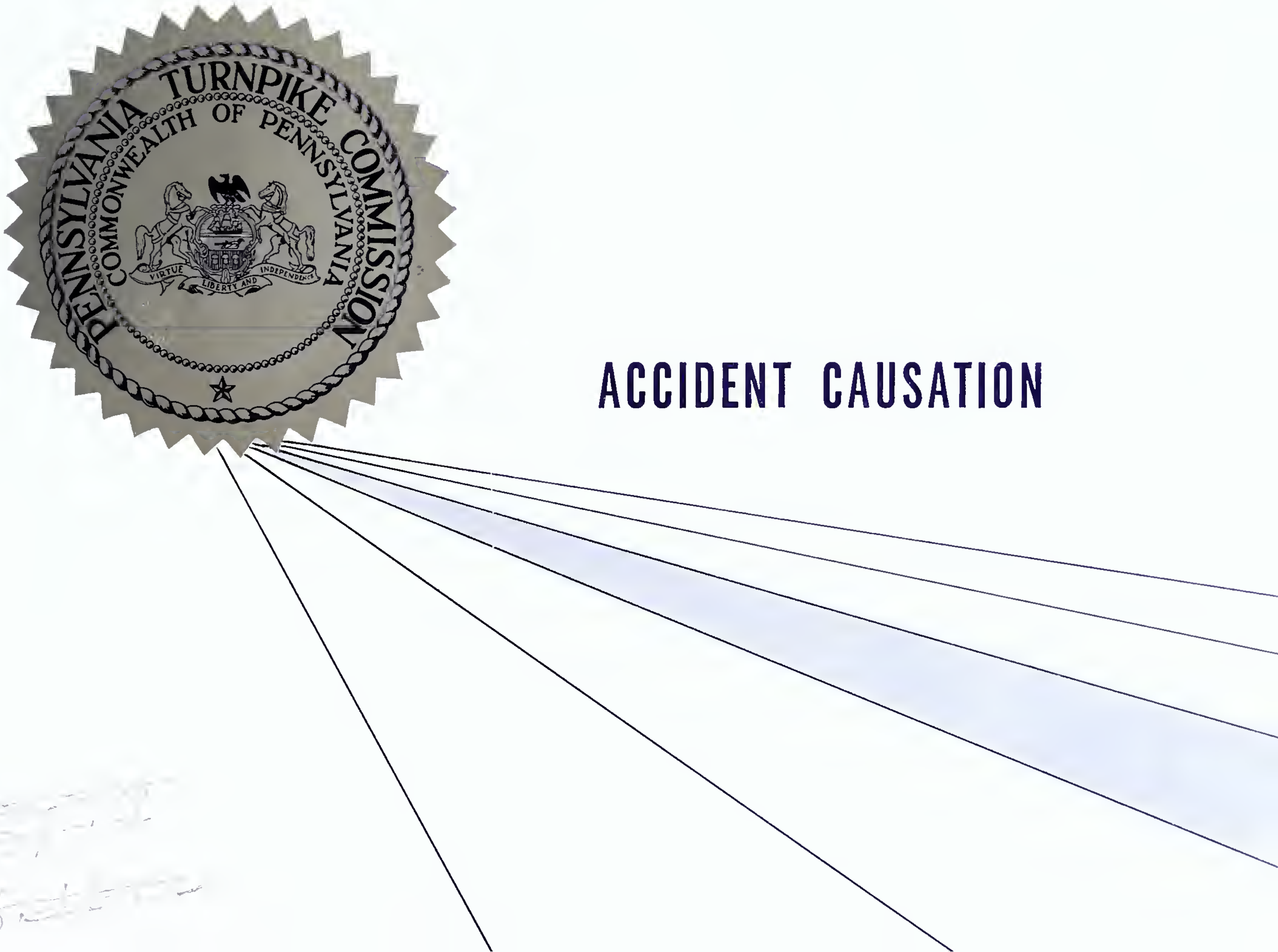
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ACCIDENT CAUSATION

PENNSYLVANIA TURNPIKE
JOINT SAFETY RESEARCH GROUP

PENNSYLVANIA TURNPIKE COMMISSION

ACCIDENT CAUSATION

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Westinghouse Air Brake Company

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The Honorable James F. Torrance
Secretary-Treasurer

The Honorable David E. Watson
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PAUL K. ECKHARDT, *Supervising Engineer*
Union Switch & Signal
Division of Westinghouse Air Brake Company

September, 1954

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CHAPTER I

HISTORY AND BACKGROUND

The history of the Pennsylvania Turnpike, while it was officially opened to public travel as recently as October 1, 1940, is the history of transportation itself. For the development of both has been patterned by the demands of an evolving civilization. The increasing complexity of modern society has necessitated ever faster, safer more efficient transportation facilities. The Pennsylvania Turnpike was born of this need.

The original 160 mile Turnpike, linking Middlesex and Irwin, marked the beginning of the super highway era of automotive travel. The most advanced highway engineering knowledge was applied in the design and construction of this road. Safety, speed and efficiency were the basic ingredients in this first link in a truly super highway system.

Extensions of this link soon connected Philadelphia with the Ohio State Line. Turnpike patrons could thus travel 327 uninterrupted miles without once encountering a grade crossing or a traffic light. Twenty-four-foot traffic lanes divided by a 10 foot medial strip and bounded by shoulders of at least 10 feet in width, made this travel fast, safe and pleasant. Additional features, including a minimum sight distance of 1000 feet, 6° maximum curve radius and 3% maximum grade, combined to keep demands on driver and vehicle at a minimum.

Public and commercial response has been enthusiastic. Since its opening the road has carried more than 57,000,000 vehicles under all types of weather and roadway conditions for a total of 5,566,000,000 vehicle miles! Year after year there has been an increase in vehicle miles driven with the peak mounting to 1,206,000,000 vehicle miles in 1953. The magnitude of the service provided by the highway is self evident.

While traffic was assuming immense proportions accident rates were exhibiting a decreasing trend with 1953 representing the fourth successive year of a drop in rate. Nevertheless accidents were a problem. Despite the fact that rates compared favorably with other highways, the 9212 accidents involving 13,426 vehicles occurring on the main line of the Turnpike since its opening could not be ignored.

Coping with the problem of accident causation is never an easy task. Countless studies over many years have failed to uncover a panacea. In the case of the Turnpike the problem was even greater. For the Turnpike was unique and previous formulae would not necessarily apply to this most modern of highways. Because the highway embodied the most advanced engineering knowledge available, it seemed likely that fault lay with some other feature of the man-machine system not amenable to engineering. But what was the nature of this fault or faults?

Expert opinion rapidly furnished "solutions." Just as in horse racing and roulette many "perfect systems" for beating the game were proposed. The Pennsylvania Turnpike Commission strongly suspected these systems would prove no more perfect than their gambling counterparts. Further, the stakes in human life and property did not justify gambling. Pennsylvania and the whole of the United States would soon be covered with a network of super highways. Facts, not opinion, were needed if this network was to realize its full potentialities. These facts were not necessarily available; they could only be assured through research.

Thus, the Joint Safety Research Group came to be. Its target was facts. Its method was basic research. Its purpose was accident reduction.

ORGANIZATION The Joint Safety Research Group was organized in October, 1952. This group had two primary research objectives, (1) to make a systematic and comprehensive analysis and evaluation of the fundamental causes of accidents on the Pennsylvania Turnpike System, (2) to make a critical analysis and evaluation of means or methods available, or to be invented, to combat causation as determined by (1).

The present report describes progress made toward achieving the first of these goals. Subsequent reports will cover further investigations, particularly those dealing with the adequacy of various remedial measures.

The organizations and their assignments in conducting this study were as follows:

A graphic breakdown of the basic factors and the inherent problem is shown in Figure I-A. The driver is seen as the central figure in the diagram, as he is in the accident problem. The broad elements, both aiding and hindering him are shown as individual circles forming an external sphere of influences.

The driver, then, is equipped with certain inherent capabilities, skills, experience, temperament, etc. He is abetted by legislation, which sets down and enforces rules intended for safe operation; administration, which maintains the roadway through repair, cindering, etc., in an effort to reduce the resourcefulness needed by the driver; publicity and education, which establish and carry out an information program designed to build up the driver's awareness of conditions; and training, which has, to date, been primarily informal driving training.

JOINT SAFETY RESEARCH GROUP

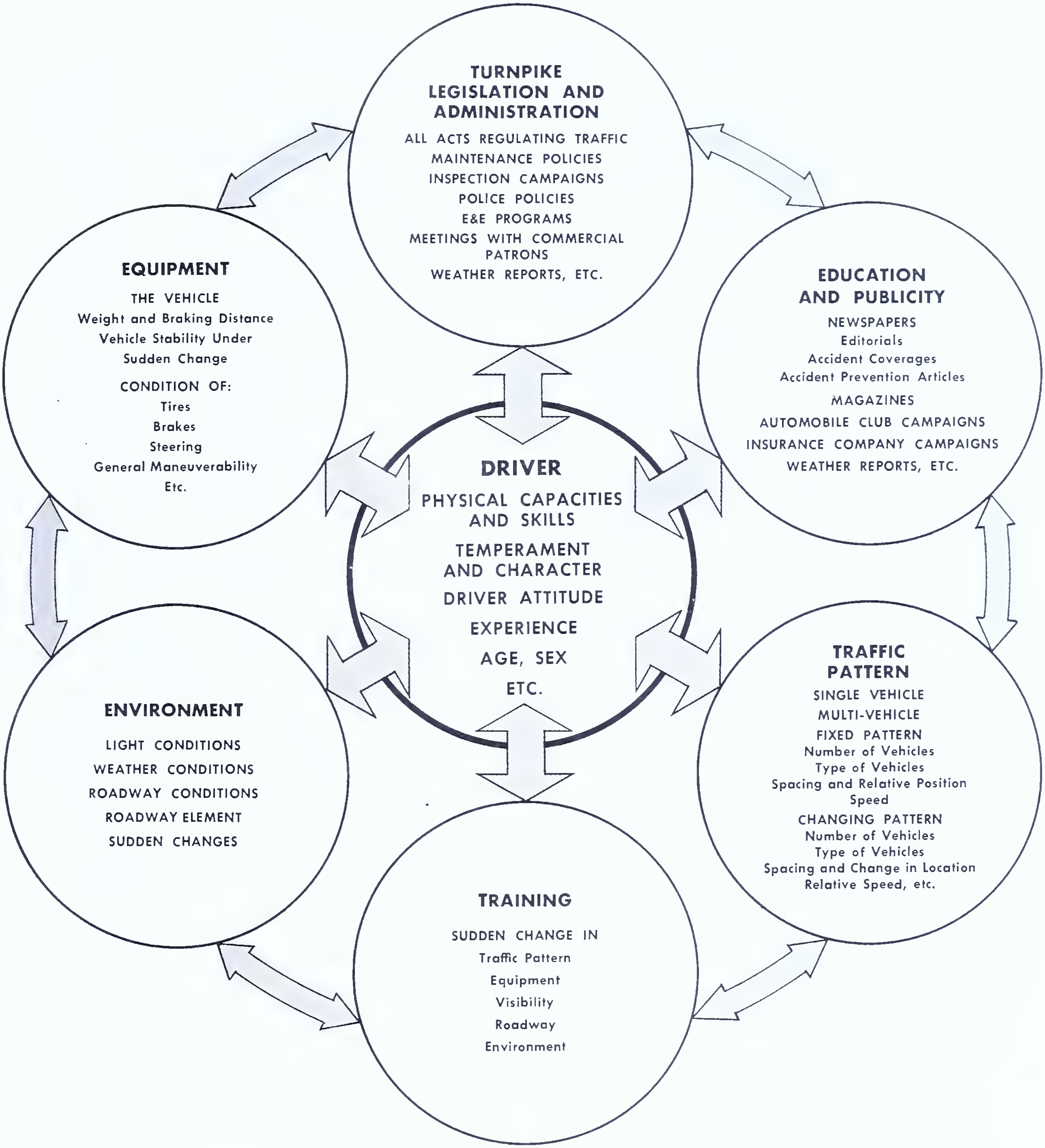
MEMBER	ASSIGNMENT
Pennsylvania Turnpike Commission J. E. Greiner Co., Baltimore, Maryland	General aid and consultant service with full knowledge of Turnpike operation
American Institute For Research Pittsburgh, Pa.	Analysis of Human Factors Surveys Remedial Research
Union Switch & Signal Division Westinghouse Air Brake Co. Swissvale, Pa.	Project Administration Environment Studies Surveys Engineering

THE PROBLEM The driver, the vehicle, the environment, legislation, administration, publicity, education and training are the main factors which play a part in express highway traffic as we know it today. Each of these factors exerts some influence on the safety with which this traffic flows. Within one, many, or all of these factors can be found the clues to accident causation.

The driver is faced with a dynamic set of environmental and vehicular conditions. The great majority of the time he succeeds in his driving task—at times there is failure. The problem consisted of determining the relative importance of each of these main factors, the full scope of each factor's role in the traffic picture, and the actions, interactions, or failures of these factors which are basic to accident causation.

FIGURE I-A

Problem Diagram



THE PLAN OF ATTACK The overall plan of attacking the problem consisted of breaking down these complex factors into their many elements and sub-elements. Once broken down these factors were to be analyzed independently and rebuilt into more complex, yet understandable, combinations. The individual analysis of the various elements and sub-elements resulted in the isolation of the most important factors.

This plan called for: (1) determination of the task difficulty of each of the environmental factors; (2) determination of the relationships between the environmental conditions and the types of accidents; (3) determination of the factors that precipitated accidents; (4) the relationship between the accident precipitating factors and the environmental conditions under which the accidents occurred.

The historical accident data used in this research project was derived from the more than 9000 Pennsylvania State Police Accident Reports compiled during the years of operation of the Turnpike (See Appendix F for sample). These reports were prepared in full by the State Police Investigating Officer for every accident occurring on Turnpike Property. These officers, although assigned to the Turnpike, are members of the Pennsylvania State Police patrol and are trained for accident investigation work.

The accident reports are made out in accordance with rules laid down by state officials. These reports, then, represent the most unbiased and complete source of accident data presently available. Checks were made on the accuracy of these data throughout the study, and included radar speed surveys, independent accident investigations for comparison purposes, near-accident interviews and other field work. These checks are described more fully in subsequent portions of this report.

The voluminous data contained in the accident reports were reduced to a workable level through a process of coding and punching pertinent facts on business machine cards. The consideration of each important factor and combination of factors was thus facilitated.

Integrated with the foregoing data were facts concerning weather and temperatures supplied by the Pennsylvania Section of the Weather Bureau Center at Harrisburg, maps from the Turnpike Commission, traffic data taken on the scene, and results of the field surveys mentioned previously.

PROGRAM With the establishment of a firm plan of attack the following program was formulated to carry out this plan*:

Phase 1.

A. Police accident report study
   1. Business machine processing and tabulation of accident reports.
   2. The analysis of environmental factors in accidents.
   3. The analysis of the human factors in accidents.
   4. The integration of human and environmental factors.

B. Review of previous accident studies.

Phase 2.

A. Field Surveys
   1. Speed analysis
   2. Accident report comparison
   3. General observations
   4. Near-Accident Surveys

**This is an outline of the broad causal study phases only. Later phases have been assigned for more detailed causal and remedial research.*

SUMMARY Probably the most concise summary of the data is contained in Tables I-1, I-2, and I-3. Here are presented in numerical form those environmental conditions under which most accidents occurred, the factors which precipitated the accidents, how the vehicle was involved, and the severity of the accidents in terms of injuries and fatalities.

As has been mentioned, the initial phases of this research project had one primary purpose in mind—to discover generally what causes accidents on the Pennsylvania Turnpike. Midway through this part of the research project the answer to this question surprisingly became apparent. Accidents are caused in a vast majority of cases by human error, and to a smaller extent, by vehicle failure—both factors influenced by the environmental conditions encountered in the driving operation. Of all accidents which occurred during 1952-1953, for example, 86.5% were precipitated by driver error while 13.5% were attributable to vehicle failures.

These accident precipitating factors can be summarized in eight broad categories: (Table II-1).

1. Failure to Cope with Road Conditions.
2. Illegal and Unsafe Actions.
3. Inattention.
4. Vehicle Failures.
5. Deficiencies in Routine Driving Skills.
6. Misperception.
7. Failure to Avoid Objects in Road.
8. Intoxicants.

By far the largest groups are those termed Failure to Cope with Road Conditions, and Illegal and Unsafe Actions. In these categories are found such things as drivers failing to cope with skids, pulling out in front of passing vehicles, and cutting in too quickly after passing. These and similar behaviors accounted for approximately 42% of all Turnpike accidents during 1952-1953.

Inattention accounted for 16.9% of all accidents during 1952-1953. Behaviors found in this class range from reaching for a pack of cigarettes or a hat on the back seat (and thus removing attention from the road ahead) to falling asleep. These latter cases, accounting for 13% of all accidents, are one example of how drivers fail under ideal conditions, since a large portion of these accidents occurred under favorable weather conditions and to the more experienced drivers. Apparently within the very ease of the driving job lie the foundations for monotony and inattentiveness.

Vehicle failures represent 13.5% of 1952-53 accidents. These include such things as brake failures, steering mechanism failures, blowouts, etc.

The accidents grouped in Deficiencies in Routine Driving Skills form 11.4% of the total. This class includes running off the roadway on curves, misjudging passing room with resulting sideswiping, turning the wrong way in skids, etc.

The Misperception category, forming 8.1% of the total, includes those accidents precipitated by misjudging the distance of the vehicle ahead. When a driver decides to pass, for example, he finds he has waited too long before cutting out, and, consequently, a rear-end collision results.

Failure to Cope With Objects in Road involves accidents resulting when drivers were unable to avoid deer, dogs, etc., appearing in their path. The Intoxication category is self-explanatory.

We have considered to this point the manner in which the driver or vehicle fails in performing the driving task. We will proceed to our findings concerning the role of environment in the overall accident picture.

The four basic or broad primary environmental factors considered can be classified as Light Conditions, Weather Conditions, Roadway Conditions, and the Roadway Element (straight, curved). These factors influence not only the drivers' behaviors and vehicles, but also may influence the vehicle exposure (vehicle miles driven under a given category) and traffic patterns.

It can be stated that the majority of accidents occurred under "ideal" environmental conditions. It is necessary, however, to look further to determine the difficulty of the driving task in terms of accident rates. (Pages 18-19.)

TABLE I-1

SUMMARY TABLE OF

MAIN ENVIRONMENTAL FACTORS	LIGHT	DAYLIGHT 58%								
	WEATHER		CLEAR OR CLOUDY 41.8-72							
	ROAD SURFACE		DRY 31.8-76		WET 23-5		SNOW/SLUSH 1.5-4		ICE 6.2-15	
	ROAD ELEMENT		STR 25.0 79	CUR 6.8 21	STR 1.6- 69	CUR 0.7 31	STR 1.1 75	CUR 0.4 25	STR 4.5 73	CUR 1.7 27
PRECIPITATING FACTORS	DEFICIENCIES IN ROUTINE DRIVING SKILLS	7.6	2.5	1.1	0.3	0.2	0.1	0.1	0.7	0.2
	ILLEGAL & UNSAFE ACTIONS	18.5	9.6	3.0	0.5	+	0.4	0.0	0.5	0.4
	FAILURE TO COPE WITH ROAD CONDITIONS	10.6	0.1	0.1	0.1	0.2	0.5	0.2	2.9	1.1
	INATTENTION	7.2	4.1	1.1	0.3	0.2	0.0	0.1	0.2	+
	MISPERCEPTION	2.9	1 4	0.2	0 1	0.0	0.1	0.0	+	0.0
	FAILURE TO AVOID OBJECTS IN ROAD	1.7	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	INTOXICANTS	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	VEHICLE FAILURES	9.1	6.4	1.1	0.2	0.1	0.0	0.0	0.2	+
TYPE OF INVOLVEMENT	PEDESTRIAN	0.3	0.2	+	+	+	0.0	0.0	+	0.0
	REAR END COLLISION	21.9	10.2	1.9	0.9	0.3	0.3	+	1.7	0.5
	LEGALLY PARKED	2.3	0.9	0.2	+	+	0.2	0.0	0.2	+
	ILLEGALLY PARKED	0.7	0.3	0.1	+	0.0	+	0.0	0.1	0.1
	RUNNING OFF ROAD	9.0	2.3	0.9	0.2	0.1	0.2	0.1	1.0	0.4
	COLLISION WITH FIXED OBJECT ON ROAD	2.0	0.9	0.4	+	+	+	+	0.1	+
	COLLISION WITH FIXED OBJECT OFF ROAD	4.7	1.6	0.8	0.1	0.1	0.1	+	0.4	0.2
	SIDESWIPE	5.5	2.7	0.6	0.2	+	0.1	+	0.4	0.1
	NON-COLLISION OVERTURNING	8.8	4.4	1.4	0.1	0.1	0.1	+	0.5	0.2
	OTHERS	2.8	1.5	0.5	+	0.0	+	+	0.0	0.0
VEHICLE INVOLVEMENT	SINGLE	18.8	8.3	2.9	0.2	0.3	0.3	0.1	1.1	0.5
	DOUBLE	31.8	14.2	3.4	1.2	0.3	0.6	0.2	2.4	1.0
	TRIPLE OR MORE	7.4	2.5	0.5	0.2	0.1	0.2	+	1.0	0.2
DEGREE OF INVOLVEMENT	FATAL	2.3	0.9	0.5	+	+	+	0.0	+	0.1
	INJURY	21.1	9.0	2.4	0.5	0.3	0.3	0.1	1.6	0.7
	PROPERTY DAMAGE	34.6	15.1	3.9	1.1	0.3	0.8	0.3	2.8	0.9

LEGEND: + INDICATES LESS THAN 0.1%, MORE THAN 0%. STR-STRAIGHT.

DAYLIGHT ACCIDENTS

PRECIPITATION 15.4-27								FOG 0.8-1							
DRY 0.3-2		WET 8.0-52		SNOW/SLUSH 2.8-19		ICE 4.3-28		DRY 0.4-56		WET 0.2-22		SNOW/SLUSH 0.0-0		ICE 0.2-22	
TR	CUR	STR	CUR	STR	CUR	STR	CUR	STR	CUR	STR	CUR	STR	CUR	STR	CUR
0.2	0.1	5.1	2.9	2.0	0.8	2.7	1.6	0.4	+	0.1+	0.1	0.0	0.0	0.1+	0.1
70	30	64	36	69	31	63	37	93	7	82	18	0	0	64	36
+	+	0.8	0.9	0.3	0.3	0.3	0.2	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.6	0.6	0.4	0.0	0.6	0.5	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	+	1.5	1.3	0.8	0.4	1.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	+	+
0.0	0.0	0.5	+	0.2	0.0	0.2	0.0	0.1	+	0.1	0.1	0.0	0.0	0.0	0.0
0.0	0.0	0.4	0.0	0.3	0.2	0.1	0.0	0.1	0.0	+	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.2	0.1	+	+	0.1	+	0.1	0.0	0.0	0.0	0.0	0.0	+	+
0.0	0.0	0.0	+	+	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	1.8	0.4	1.0	0.4	1.3	0.5	0.3	+	+	+	0.0	0.0	0.1	+
0.0	+	0.2	+	0.2	+	0.1	+	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0
0.0	0.0	+	+	+	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	1.2	0.7	0.4	0.2	0.5	0.4	+	0.0	0.0	0.0	0.0	0.0	+	+
+	0.0	0.2	0.1	+	+	0.1	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	+	0.4	0.4	0.1	+	0.2	0.1	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	+	0.4	+	0.3	0.2	0.3	+	+	0.0	+	0.0	0.0	0.0	0.0	0.0
+	+	0.7	0.5	0.2	0.1	0.3	0.2	+	0.0	+	0.0	0.0	0.0	+	+
+	0.0	0.2	+	+	+	0.1	+	+	0.0	+	0.0	0.0	0.0	+	0.0
+	+	1.6	1.3	0.4	0.2	0.7	0.5	0.1	+	+	0.0	0.0	0.0	+	+
0.1	+	2.4	0.7	1.5	0.4	1.5	0.8	0.2	0.0	0.1	+	0.0	0.0	+	+
0.0	0.0	1.1	+	0.4	0.2	0.5	0.3	0.1	+	0.0	0.0	0.0	0.0	+	0.0
+	+	0.2	0.2	+	+	+	+	+	0.0	0.0	0.0	0.0	0.0	0.0	+
0.1	+	2.0	1.2	0.5	0.3	1.0	0.5	0.2	0.0	+	+	0.0	0.0	+	0.0
0.1	+	2.9	1.5	1.5	0.5	1.7	1.0	0.2	+	+	0.0	0.0	0.0	+	+

CUR - CURVED.

TABLE I-2

SUMMARY TABLE OF

MAIN ENVIRONMENTAL FACTORS	LIGHT	DARKNESS 36 %								
	WEATHER		CLEAR OR CLOUDY 24.2-67							
	ROAD SURFACE		DRY 19.8-82		WET 1.6 - 6		SNOW/SLUSH 0.3-1		ICE 2.5-11	
	ROAD ELEMENT		STR 15.4 77	CUR 4.4 23	STR 1.2 74	CUR 0.4 26	STR 0.2 88	CUR 0.1 12	STR 1.7 70	CUR 0.8 30
PRECIPITATING FACTORS	DEFICIENCIES IN ROUTINE DRIVING SKILLS	3.6	0.7	1.2	0.2	0.2	0.0	0.0	0.0	0.3
	ILLEGAL & UNSAFE ACTIONS	8.2	3.4	0.8	0.3	+	0.0	0.0	0.3	0.0
	FAILURE TO COPE WITH ROAD CONDITIONS	4.7	0.1	0.0	0.1	0.0	+	+	1.0	0.5
	INATTENTION	6.9	4.5	0.9	0.3	+	+	+	0.0	0.0
	MISPERCEPTION	4.6	2.1	0.3	0.1	0.1	+	0.0	0.4	0.0
	FAILURE TO AVOID OBJECTS IN ROAD	3.0	1.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0
	INTOXICANTS	0.7	0.5	0.2	0.0	0.0	+	0.0	0.0	0.0
	VEHICLE FAILURES	4.3	2.7	0.8	0.1	+	0.0	0.0	+	0.0
TYPE OF INVOLVEMENT	PEDESTRIAN	0.3	0.1	+	0.0	0.0	0.0	0.0	0.0	+
	REAR END COLLISION	16.1	7.5	1.5	0.6	0.1	+	+	0.7	0.3
	LEGALLY PARKED	1.7	0.7	0.1	+	0.0	+	0.0	0.1	+
	ILLEGALLY PARKED	1.2	0.5	0.1	+	0.0	0.0	0.0	0.1	+
	RUNNING OFF ROAD	3.9	1.1	0.5	0.1	0.1	+	0.0	0.1	0.1
	COLLISION WITH FIXED OBJECT – ON ROAD	1.9	1.0	0.3	0.1	0.1	+	0.0	+	0.0
	COLLISION WITH FIXED OBJECT – OFF ROAD	2.3	0.8	0.3	+	+	+	+	0.3	0.1
	SIDESWIPE	2.7	1.0	0.3	0.1	+	0.0	0.0	0.2	0.1
	NON-COLLISION OVERTURNING	4.7	2.1	1.1	0.1	+	+	0.0	0.2	0.1
	OTHER	1.2	0.6	0.2	+	+	0.0	0.0	+	0.0
VEHICLE INVOLVEMENT	SINGLE	11.0	4.4	2.1	0.4	0.3	+	+	0.5	0.2
	DOUBLE	21.0	10.2	1.9	0.7	0.1	0.1	0.0	1.0	0.5
	TRIPLE OR MORE	4.0	0.8	0.4	0.1	+	0.0	+	0.2	0.1
DEGREE OF INVOLVEMENT	FATAL	1.9	0.9	0.5	+	+	0.0	0.0	0.1	0.1
	INJURY	12.4	4.9	1.7	0.3	0.2	0.1	+	0.5	0.3
	PROPERTY DAMAGE	21.7	9.6	2.2	0.8	0.2	0.1	+	1.1	0.4

LEGEND: + INDICATES LESS THAN 0.1%, MORE THAN 0%. STR – STRAIGHT

ARKNESS ACCIDENTS

PRECIPITATION 10.3-29								FOG 1.5-4							
DRY 0.2-2		WET 4.2-41		SNOW/SLUSH 1.5-15		ICE 4.4-42		DRY 0.7-50		WET 0.5-30		SLUSH/SNOW + 1		ICE 0.3-19	
TR 2 3	CUR + 27	STR 3.0 73	CUR 1.2 27	STR 1.2 81	CUR 0.3 19	STR 2.7 61	CUR 1.7 39	STR 0.6 78	CUR 0.1 22	STR 0.4 80	CUR 0.1 20	STR + 100	CUR 0.0	STR 0.2 84	CUR + 16
.0	0.0	0.3	0.3	0.1	+	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	1.1	0.2	0.3	+	0.9	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
.0	+	0.4	0.2	0.8	+	1.6	0.8	0.0	0.0	0.0	+	0.0	0.0	+	+
.2	+	0.4	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.7	0.2	0.0	+	0.0	0.3	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0
+	+	0.1	0.2	0.0	+	0.0	0.0	+	0.0	0.1	+	0.0	0.0	0.0	0.0
.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	0.0	0.0	0.0	0.0	0.0	+	0.1	+	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	+	+	0.0	+	0.0	0.0	+	+	0.0	0.0	0.0	0.0	0.0
.1	+	1.4	0.3	0.6	0.1	1.2	0.7	0.4	+	0.2	+	+	0.0	0.2	+
.0	0.0	0.2	+	0.1	0.0	0.1	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	+	+	+	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	+	0.4	0.3	0.2	+	0.6	0.3	+	0.0	+	+	0.0	0.0	0.0	+
+	+	0.2	+	+	0.0	0.1	+	+	+	+	0.0	0.0	0.0	0.0	0.0
+	+	0.2	0.1	+	+	0.1	0.1	+	+	+	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.2	+	0.1	0.1	0.1	0.2	0.1	0.0	+	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.4	0.1	0.1	+	0.3	0.2	+	+	+	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	+	+	+	0.1	+	+	+	+	0.0	0.0	0.0	0.0	0.0
+	+	0.9	0.7	0.2	+	0.7	0.4	0.1	+	0.1	0.0	0.0	0.0	+	0.0
.1	+	1.7	0.4	0.8	0.2	1.4	0.8	0.4	+	0.2	+	+	0.0	0.1	+
+	0.0	0.4	0.1	0.2	0.1	0.6	0.5	0.1	+	0.1	+	0.0	0.0	0.1	+
.0	0.0	0.1	0.1	+	0.0	+	+	+	0.0	+	0.0	0.0	0.0	+	0.0
.1	+	1.1	0.5	0.4	0.1	0.9	0.6	0.2	0.1	0.1	0.1	0.0	0.0	0.1	+
.1	+	1.8	0.6	0.8	0.2	1.8	1.1	0.4	+	0.3	+	+	0.0	0.1	+

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TABLE I-3

SUMMARY TABLE OF

MAIN ENVIRONMENTAL FACTORS	LIGHT	DAWN AND DUSK 6%								
	WEATHER		CLEAR OR CLOUDY 3.9-66							
	ROAD SURFACE		DRY 2.9-74		WET 0.4-10		SNOW/SLUSH 0.1-3		ICE 0.5-13	
	ROAD ELEMENT		STR 2.2 78	CUR 0.7 22	STR 0.3 72	CUR 0.1 28	STR 0.1 86	CUR + 14	STR 0.4 77	CUR 0.1 23
PRECIPITATING FACTORS	DEFICIENCIES IN ROUTINE DRIVING SKILLS	0.7	0.2	0.0	0.0	+	+	0.0	0.0	0.1
	ILLEGAL & UNSAFE ACTIONS	1.3	0.6	0.1	+	+	+	0.0	0.1	0.0
	FAILURE TO COPE WITH ROAD CONDITIONS	1.4	0.0	0.1	0.0	0.0	+	+	0.2	0.0
	INATTENTION	0.7	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	MISPERCEPTION	0.5	+	+	0.1	0.0	0.0	0.0	+	0.0
	FAILURE TO AVOID OBJECTS IN ROAD	0.2	0.2	0.1	0.0	0.0	0.0	+	0.0	0.0
	INTOXICANTS	0.1	+	0.0	+	0.0	0.0	0.0	0.0	0.0
	VEHICLE FAILURES	1.1	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0
TYPE OF INVOLVEMENT	PEDESTRIAN	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	REAR END COLLISION	2.3	0.8	0.1	0.1	+	+	+	0.1	+
	LEGALLY PARKED	0.4	0.2	+	+	0.0	+	0.0	+	0.0
	ILLEGALLY PARKED	0.1	+	0.0	0.0	0.0	0.0	0.0	+	0.0
	RUNNING OFF ROAD	0.9	0.3	0.1	+	+	+	+	+	+
	COLLISION WITH FIXED OBJECT — ON ROAD	0.2	0.1	+	+	+	0.0	0.0	+	0.0
	COLLISION WITH FIXED OBJECT — OFF ROAD	0.4	0.2	+	+	+	+	0.0	+	+
	SIDESWIPE	0.5	0.2	+	+	0.0	+	0.0	+	0.0
	NON-COLLISION OVERTURNING	0.8	0.3	0.1	+	0.0	0.0	0.0	+	+
	OTHERS	0.3	0.1	+	0.0	0.0	+	0.0	0.0	0.0
VEHICLE INVOLVEMENT	SINGLE	2.1	0.7	0.4	0.1	+	+	0.0	0.1	+
	DOUBLE	3.2	1.3	0.3	0.2	0.1	0.1	+	0.2	+
	TRIPLE OR MORE	0.7	0.2	0.0	0.0	0.0	+	0.0	+	0.0
DEGREE OF INVOLVEMENT	FATAL	0.3	0.2	0.0	0.0	0.0	0.0	0.0	+	0.0
	INJURY	2.1	0.7	0.3	0.1	0.1	0.0	+	0.1	+
	PROPERTY DAMAGE	3.6	1.3	0.4	0.2	+	0.1	0.0	0.2	0.1

LEGEND: + INDICATES LESS THAN 0.1%, MORE THAN 0%. STR - STRAIGHT.

DAWN AND DUSK ACCIDENTS

PRECIPITATION 1.7-28								FOG 0.4-7							
DRY 0.1-7		WET 0.8-44		SNOW/SLUSH 0.2-12		ICE 0.6-37		DRY 0.2-65		WET 0.1-16		SNOW/SLUSH 0.0-0		ICE 0.1-19	
TR .1 00	CUR 0.0 0	STR 0.5 56	CUR 0.3 44	STR 0.2 84	CUR + 16	STR 0.4 58	CUR 0.2 42	STR 0.2 76	CUR + 24	STR + 50	CUR + 50	STR 0.0 0	CUR 0.0 0	STR + 80	CUR + 20
+	0.0	0.0	+	+	0.0	+	0.0	0.0	0.0	+	0.0	0.0	0.0	+	+
+	0.0	+	0.0	0.0	0.0	+	+	+	0.0	+	0.0	0.0	0.0	+	+
+	0.0	+	0.3	+	+	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	+	0.0	0.0	+	+
+	0.0	0.0	0.0	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	0.1	+	0.1	+	0.1	+	0.1	0.0	0.0	0.0	0.0	0.0	+	0.0
.0	0.0	+	0.0	+	0.0	+	0.0	+	0.0	+	0.0	0.0	0.0	0.0	0.0
.0	0.0	0.0	0.0	+	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	+	0.0
+	+	+	+	0.0	0.0	0.0	0.0	+	0.0	+	+	0.0	0.0	+	+
.0	0.0	+	0.0	+	0.0	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
.0	0.0	+	+	+	0.0	+	0.0	0.0	+	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	+	0.0	0.0	0.0	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	+	+	0.0	0.0	+	0.1	+	+	0.0	+	0.0	0.0	0.0	0.0
+	0.0	0.0	+	+	+	0.0	+	+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	0.2	0.1	+	0.0	0.1	0.1	+	+	0.0	+	0.0	0.0	0.0	0.0
.1	0.0	0.2	0.1	0.1	+	0.2	0.1	0.1	0.0	+	+	0.0	0.0	+	+
.0	0.0	+	+	+	+	0.1	+	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+	0.0	+	+	0.0	0.0	+	0.0	+	0.0	0.0	+	0.0	0.0	0.0	0.0
.1	0.0	0.1	0.1	0.1	+	0.1	0.1	0.1	+	+	0.0	0.0	0.0	+	0.0
+	0.0	0.3	0.2	0.1	0.0	0.2	0.1	0.1	+	+	+	+	0.0	+	+

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TABLE I-4

Accident Rates for Weather Conditions

Clear-Cloudy	1.2 accidents per million vehicle miles
Fog	1.3 accidents per million vehicle miles
Precipitation	2.5 accidents per million vehicle miles

The data indicate that both fog and precipitation are more difficult conditions than clear-cloudy. Conditions of precipitation are more than twice as troublesome as those of clear-cloudy weather.

TABLE I-5

Accident Rates for Roadway Conditions

Dry	1.1 accidents per million vehicle miles
Wet	1.9 accidents per million vehicle miles
Snow-Slush	4.8 accidents per million vehicle miles
Icy	8.2 accidents per million vehicle miles

Here again we find the "ideal" condition, dry roadway, is less difficult to negotiate than any of the others. Icy roadway for example, is almost eight times more troublesome than dry roadway.

TABLE I-6

Accident Rates for Light Conditions

Day	1.5 accidents per million vehicle miles
Night*	1.5 accidents per million vehicle miles

**(Including dusk and dawn)*

The breakdown of Light Conditions (Chapter III) indicates that some of the accident experiences found during daylight hours fall off during darkness hours while others increase to compensate for the drop-off. This balancing effect is such to keep the rates approximately the same, as will be noted in subsequent chapters of this report.

TABLE I-7

Accident Rates for Roadway Elements

Straight Roadway	1.5 accidents per million vehicle miles
Curved Roadway	1.5 accidents per million vehicle miles

For purposes of computation of these rates, straight roadway includes all roadway from 0° to 30′ curvature, and curved roadway includes all roadway over 30′ of curvature. Thus, straight road accounts for approximately the same general accident rate as does curved roadway. While a curved road is probably more difficult from the point of view of the driving task, drivers might, and apparently do, compensate for this increased difficulty by exercising a greater degree of alertness and care. Straight roadway on the other hand, is relatively easy from the point of view of driving task difficulty. This very ease, as in the case of clear and cloudy weather, may serve to generate the overconfidence and inattentiveness which lead to many accidents. Points such as these are deserving of further consideration in future research studies.

While the preceding tables have considered rates from the point of view of *accidents*, vehicle *involvement* rates also reveal a similar pattern. These are presented in Table I-8 for comparison purposes.

TABLE I-8

Vehicle Involvement Rates

	Estimated Millions of Vehicle Miles Traveled (1952)	*Vehicle Involvement in Accidents (1952)	Rate
Light Conditions:			
Daylight	685	1599	2.3
Night + Dusk & Dawn	457	1126	2.5
Weather Conditions:			
Clear-Cloudy	945	1849	2.0
Fog	34	91	2.7
Rain	111	435	3.9
Snow	85	346	4.1
Sleet, Freezing Rain, Hail	2	12	6.0
Roadway Conditions:			
Dry	879	1503	1.7
Wet	206	608	3.0
Snow-Slush	23	181	7.9
Ice	34	440	12.9
Roadway Elements:			
Straight	828	2058	2.5
Curved	314	654	2.1

**Vehicle involvement figures do not include unknowns. Totals for the various categories may differ.*

The question arises as to how dry roadway and clear-cloudy weather can be both those conditions under which most accidents occurred, and yet those most easy in terms of driving task difficulty, as indicated by their estimated accident rates. The answer lies in the fact that these conditions are those under which we find the greatest volume of traffic traveling the Turnpike. While fewer vehicles, per vehicle mile traveled, are involved in accidents under "ideal" conditions, the number of vehicles and vehicle miles driven under these conditions is so large that a majority of the accidents result.

Inherent in the above paragraphs is the implication of a close relationship between exposure (vehicle miles driven) and accident frequency. Such a relationship has been found and is illustrated according to day of week traffic and accidents, in the following table:

TABLE I-9

Comparison of Accidents By Day of Week to Traffic By Day of Week—(1952-1953 Data)

Day of Week	April, 1953 (% of total* traffic)	August, 1953 (% of total* traffic)	Accidents (1952) (% of total)
Sunday	20.4	19.6	18.9
Monday	12.2	12.2	13.8
Tuesday	11.3	11.7	11.0
Wednesday	12.7	12.2	12.6
Thursday	12.5	12.3	11.1
Friday	15.8	15.4	12.4
Saturday	15.1	16.7	20.2

**Various checks were made as part of the radar studies to insure that the above percentages of traffic by day of week were representative for the period of this study. They were found to be representative.*

It is apparent that the percentage of accidents occurring on any given day varies fairly closely with the percentage of total traffic traveling on that day. It should be added that the gross grouping used in this table masks certain differences made explicit in another section of this report. (Chapter II) For general purposes, however, Table I-9 does serve to point out the close agreement between exposure and accident frequency generally.

With the foregoing discussion of human, vehicular and environmental factors we are prepared to cover the relationships discovered among these factors. What influence did the environmental conditions have on the human behaviors and the vehicular factors?

Generally, each of the four major environmental conditions was found to play an important role in modifying driver behavior. One interesting example of environmental influence on driver behavior was previously mentioned in this chapter, i.e., the significantly high number of falling asleep accidents during clear-cloudy weather conditions. In addition, vehicular failures were also found to be disproportionately high during clear-cloudy conditions.

Truck drivers were found to be involved in a disproportionately high number of accidents on wet roadway as a result of misperception.

These and other specific relationships are covered in detail in Chapter III and should serve as a basis for further studies in connection with remedial measures.

Environmental conditions also were related to the type of accident occurrence. The most frequently occurring accident type was the rear end collision which accounted for 29.0% of total passenger car-precipitated accidents and 38.6% of total truck-precipitated accidents (1952-1953). These accidents, precipitated primarily by such driver behaviors as falling asleep, illegal and unsafe actions and misperception, were found to be significantly high during darkness hours on straight-up roadway.

As with other accident factors considered, the majority of most types of accidents occurred under the "best possible" environmental conditions. It should be remembered, in considering the data, that high accident frequency under a certain condition does not necessarily indicate significant relationships between that condition and other variables. For example, while 55.4% of all passenger car rear end collisions occurred during daylight conditions, and whereas 32.7% occurred during darkness highway unlighted conditions, passenger car rear end collisions were significantly high during darkness highway unlighted and significantly low during daylight. (Tables III-2 and 3.) Meaning that rear-end collisions occurred more often during darkness hours and less often during daylight hours than would be expected on the basis of chance factors alone.

Before concluding this summary, two subjects are worthy of consideration in view of the universal publicity they received in connection with Turnpike accidents.

The first of these subjects is the severity of the accident. Accident severity can be judged in terms of the number of injuries and fatalities accounted for by the accident. There were 62 accidents involving fatalities on the Turnpike during 1952. Of these, 22% were unclassifiable because of the death of all concerned or lack of information due to some other reason. Of those which could be classified, 97.9% were attributable to human error. The driver failures which precipitated these accidents are identical with those precipitating non-fatal accidents. Accidents involving fatalities are not, therefore, a class peculiar unto themselves and, consequently, remedial measures which reduce accidents in general may be expected to reduce fatal accidents simultaneously. See behavioral table, Chapter II.

The second much publicized factor concerns the matter of speed. Contrary to popular belief, drivers do not tend to test how fast they can go when traveling the Turnpike. This conclusion is based on the results of radar speed surveys covering several months time under all weather conditions at different points along the Turnpike. This survey covered approximately 27,500 vehicles including 17,600 passenger cars and 9,900 trucks. The ten mile spread in which most passenger cars travel the Turnpike is from 53-63 miles per hour. For trucks the spread is from 45-55 miles per hour. The accident records indicate that most accidents occur in the 41-50 mile per hour speed range. It is our opinion, even when allowing some increase beyond the speed range of the accident reports, that far from turning into destructive demons, drivers tend to travel at that speed which "feels" most comfortable to them.

This "feeling" of comfort is not necessarily reliable and may even be deceptive to the driver in some cases. Radar speed checks also indicate that drivers slow down slightly on icy and snowy roads. While this demonstrates recognition of a hazardous situation it must be concluded that the reduction in speed alone did not reduce the demands on the driver to the point where they matched his capabilities in many cases. Drivers apparently ignore wet roadway as a potential hazard, at least insofar as was indicated by speed measurement. Radar checks indicated that speeds for passenger cars and trucks were approximately the same on both wet and dry roadway.

CONCLUSIONS Accidents are basically the result of human error. Exceptions to this statement consist of vehicular failures (although these may frequently result from driver negligence in checking his vehicle). These exceptions, however, account for but a small percentage of the overall accident total.

Human error, or accident causing behavior, is not restricted to adverse environmental conditions. The task confronting the driver on the Turnpike is relatively easy for the great majority of the vehicle miles driven. Ideal environmental settings and modern vehicles are the rule rather than the exception. Even so, accidents result.

The possibility of human error, however, is compounded under the more severe environmental conditions.

As evidenced by the accident rates, as severity of environmental conditions increases, the difficulty of the driving task increases. As greater demands are placed on driver ability, human error increases disproportionately.

Under all environmental conditions some drivers underestimate the requirements of the driving task or overestimate their ability in avoiding accident situations. Drivers are apparently aware of the increased demands of adverse environmental conditions, but even here they underestimate the driving task. The lower rates of speed on icy road, as recorded by radar speed checks, and the lower estimated initial speeds of vehicles involved in accidents on icy roadway, are indications of driver awareness of the increased hazards of this condition. The compensation in speed itself was either not great enough, or more than a compensation in speed was called for, if these accidents were to be avoided. Proper compensation, greater driving ability and increased attentiveness, could have prevented most of these accidents.

The human errors which cause accidents are not flagrant in all cases. A slight error can cause as large an accident as the complete disregard of safe operating procedures. The first step necessary or prerequisite to effective remedial measures lies in the complete understanding on the part of the driving public that the driver causes accidents. The driver, in this connection, does not refer to some nebulous "they". The "driver" includes every person behind the wheel of a moving vehicle. Before remedial measures can be effectively carried out the full realization must be impressed on the public generally that every driver has, at one time or another, or perhaps on a number of occasions, been guilty of potential-accident-causing-behaviors.

Remedial considerations, then, primarily involve the necessity of educating people to recognize the part they play in the accident picture. Education, in this sense, would involve a broad area ranging from publicity and safety campaigns to driver training, and possibly would include such things as wayside instructions for drivers. When it is certain that drivers are fully aware of the role their various actions play in accident causation, monitoring or policing of these actions will be greatly simplified.

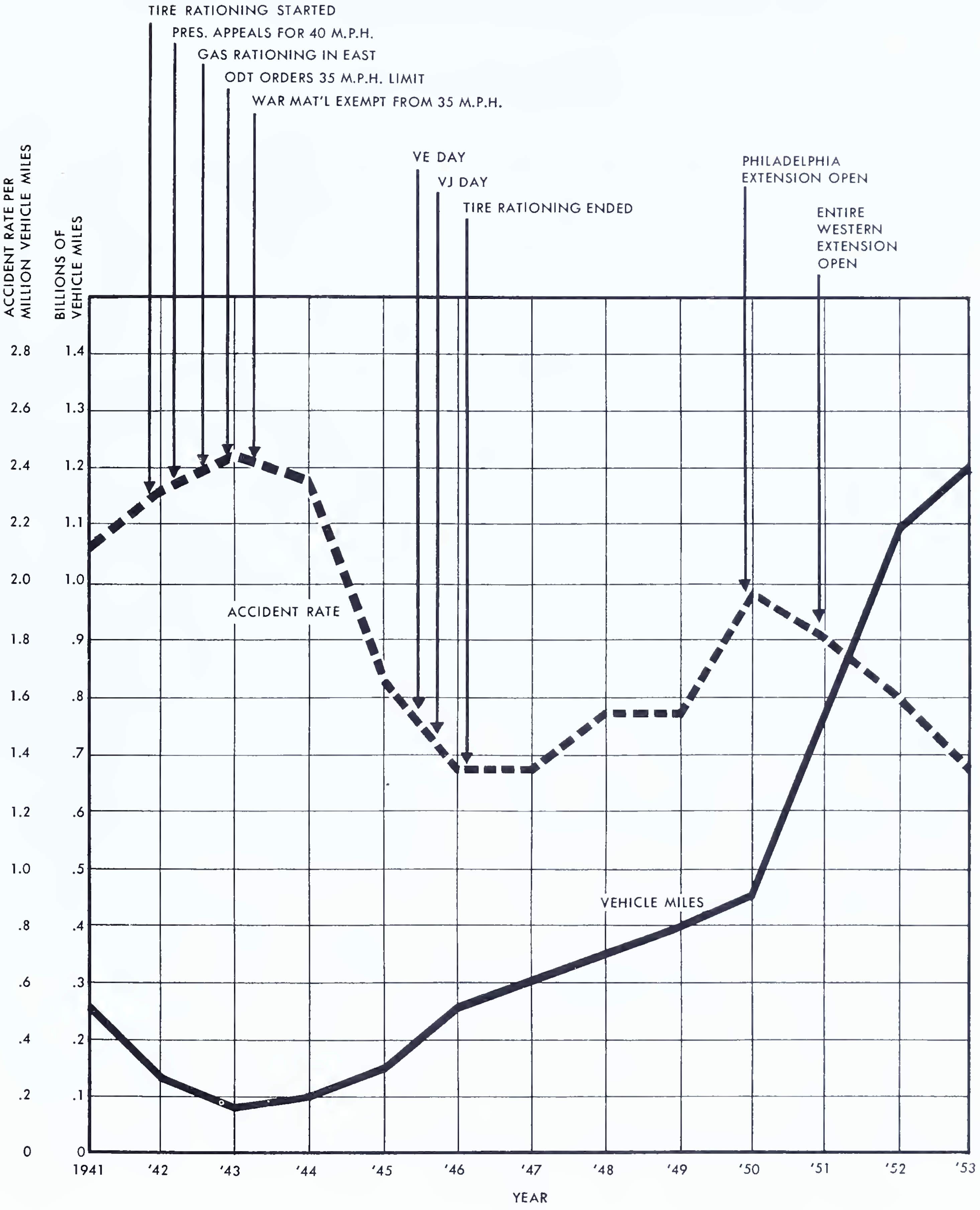
That education is a practical remedy is indicated in part by the graph presented on page 23. Accident rates for recent years show a steady decline even though traffic volume in terms of vehicle miles exposure is steadily increasing. The proportions of failures by type of failure remain the same regardless of the overall rate-indicating each category drops when the rate is down. We feel this trend may be related in part at least, to benefits derived from expanded safety campaigns, police monitoring, and driver education in recent years.

Any remedial program must of necessity be long range in nature. Education with all of its implications plus the design of technical supports for the driving task must work together. The data, however, indicate that to a small degree, benefit may be derived immediately from adopting such measures as instructing the driver as to proper car handling under transient hazardous driving conditions.

Accidents do not just happen—they are caused. They are primarily the result of driver error in failing to adequately modify his behavior to cope with the driving environment. Accidents are preventable. Driver education and training appears to be, at the present time, the most promising key to accident reduction.

FIGURE I-B

VARIATION OF ANNUAL ACCIDENT RATE
AND
ANNUAL VEHICLE MILES FOR PENNSYLVANIA TURNPIKE



CHAPTER II

HUMAN AND VEHICULAR FACTORS RELATED TO TURNPIKE ACCIDENTS

INTRODUCTION In discussing traffic accidents it is common to speak of the behavior of the automobile or the environmental conditions rather than the pertinent driver behavior. For example, we read of a vehicle running off the road, skidding on ice, or running into the rear of the vehicle ahead. Such phrases may be descriptive of actual accident events but they tend to shift focus away from the driver. It will become evident in the following pages that such a shift in emphasis is not compatible with the facts. For our basic finding is that primary responsibility for accident causation must be placed with the driver and, to a lesser extent, to vehicular failures, keeping in mind, of course, that driver behavior and the performance of the vehicle are influenced by the driving environment.

PROCEDURE One of the prime goals of the Joint Highway Safety Research Group was the description and definition of driver behaviors that led directly to accident involvement. In attaining this goal, Turnpike accident report forms filled in by the State police were carefully reviewed for statements from which driver behaviors could be abstracted. This information was obtained from statements made by the drivers involved in the accidents, passengers in the accident-vehicles, disinterested witnesses and the investigating officers. In a surprisingly small number of cases (approximately six per cent) were substantial disagreements found. Controversial reports were eliminated from further analysis. The accuracy of those reports retained for analysis was checked by field survey work which testified to their adequacy.

Careful comprehensive review of each report led to a brief statement summarizing the factor which led directly to the accident. This statement was written for each accident report for the year of 1952. These statements were then sorted into groups on the basis of similarity, e.g., all behaviors which seemed to indicate a deficiency in routine driving skill were grouped together, all accidents involving drivers who fell asleep were grouped together, etc. This procedure resulted in eight major areas of casual factors: Deficiencies in Routine Driving Skills, Illegal and Unsafe Actions, Failure to Avoid Objects in the Road, Failure to Cope With Road Conditions, Inattention, Misperception, Intoxicants, and Vehicle Failures. The complete classification of factors is presented in Table II-1.

A similar analysis of 1953 Turnpike accident report forms was carried out with the exception that the detailed statements of causal behaviors were sorted under the categories defined in the analysis of 1952 accidents. A product-moment correlation of .94 was obtained between the 1952 and 1953 data grouped under 52 category headings. This would seem to indicate that, other things being equal, accidents of various types may be expected to appear each year in roughly the same proportions.

CLASSIFICATION OF CAUSAL FACTORS Of the 3,118 accidents classified for the 1952-1953 period, 86.5 per cent were precipitated directly by human error; 13.5 per cent by vehicle failure. (One hundred ninety-nine accidents were unclassifiable because the reports lacked sufficient information.)

TABLE II-1

Classification of factors related to Turnpike accidents during 1952

	Accidents	
	Non-Fatal	Fatal
I. Failure to Cope With Road Conditions (386)		
1. Ice and Snow	168	2
a. Skidded off uncindered snowy highway	5	
b. Skidded into guard rail when trying to stop on icy highway and berm	3	
c. Skidded into parked vehicle while traveling on icy highway	4	1
d. Spun around and blocked snowy highway	5	
e. Ran off snowy highway (couldn't determine berm) lost control coming back on	6	
f. Spun on icy highway and blocked it	8	
g. Ran off road, lost control on icy road when trying to get back on	2	
h. Skidded on icy highway and lost control	67	1
i. Jack-knifed on icy highway	7	
j. Skidded into vehicle while passing on icy highway	11	
k. Struck ice on bridge and lost control	4	
l. Skidded on ice and blocked highway	3	
m. Applied brakes on icy road, skidded into vehicle	3	
n. Skidded off icy road while passing	2	
o. Struck pile of snow from snow-plow and lost control	2	
p. Applied brakes to slow down on icy road and lost control	16	
q. Tried to slow up on icy road, struck slower or stopped vehicle in rear	15	
r. Thrown in front of vehicle by snow while passing	2	
s. Skidded on icy road while passing, blocked road and was hit	1	
t. Skidded onto highway into path of vehicle while trying to stop on icy berm	1	
u. Trailer began to weave on icy road, spun out of control	1	
2. Wet	96	5
a. Skidded on wet highway and lost control	79	5
b. Slid off wet highway, skidded on soft berm, lost control	1	
c. Applied brakes on wet road, skidded into vehicle	4	
d. Skidded off wet road while passing	1	
e. Applied brakes to slow down on wet road and lost control	6	
f. Hit dividing line between lanes and skidded on wet highway	2	
g. Slid into rear of vehicle slowing up on wet highway	1	
h. Car hit bump in road and slid off wet highway	1	
i. Skidded while passing on highway	1	
3. Slush	15	0
a. Struck slushy spot and lost control	4	
b. Lost control on roadway partially slush-covered	2	
c. Skidded into vehicle while passing on slush-covered passing lane	6	
d. Lost control in uncindered slush with ruts	2	
e. Slid into rear of vehicle slowing up on slushy highway	1	
4. Icy Spots	55	0
a. Struck icy spot and lost control	50	

	Accidents	
	Non-Fatal	Fatal
b. Struck uncindered icy spot and lost control	2	
c. Struck icy spot while passing and lost control	2	
d. Struck icy spot while passing, slid into vehicle	1	
5. Wet Spots	2	0
a. Struck wet spot and lost control	1	
b. Slid on wet asphalt in interchange exit, rest of road dry	1	
6. Slick Spots	11	0
a. Hit slippery spot, skidded and lost control	11	
7. Mud	3	0
a. Skidded on mud covered roadway	3	
8. Soft Berm and Medial	7	0
a. Wind caused skid into berm, mud on wheels then resulted in skid	1	
b. Drove onto soft berm to avoid skidding car, lost control	2	
c. Started to park, skidded on soft muddy berm into rear of parked vehicle	2	
d. Hit soft spot on berm—truck tilted while parked	2	
9. Oil Scum	1	0
a. Skidded on oil scum in tunnel while trying to stop	1	
10. Wind	6	0
a. Wind caused trailer to sway—went out of control	5	
b. Wind caused vehicle to sway, skidded into guard rail	1	
11. Unknown	15	0
a. Skidded off road into guard rail	3	
b. Skidded into vehicle when entering station	3	
c. Skidded in front of vehicle while passing	2	

	Accidents	
	Non-Fatal	Fatal
d. Skidded off road when cutting in after passing	5	
e. Went into slide and hit guard rail	1	
f. Skidded and lost control when trying to enter roadway from berm	1	

II. Illegal and Unsafe Actions (475)

	Accidents	
	Non-Fatal	Fatal
1. Entering or Leaving Traffic	6	0
a. Tried to enter pike from station entrance lane	1	
b. Noticed exit at last minute, entered too fast, lost control	1	
c. Got on wrong entrance ramp, quickly swerved to other ramp and struck vehicle	1	
d. Failed to look for oncoming traffic, pulled in front of passing vehicle	2	
e. Started up in station without checking for other moving vehicles	1	
2. Improper Passing	99	2
a. Tried to pass cindering truck on icy road—truck was in middle of road	1	
b. Tried to pass when preceding vehicle kept throwing slush on windshield	1	
c. Attempted to pass in No Passing Zone (Tunnel or exit or station entrance)	8	
d. Passed vehicle on right side	16	
e. Cut in front of vehicle to get to exit or entrance	3	
f. Cut in too quickly after passing	18	
g. Wouldn't let bus pass him, passed on right, cut bus off	1	
h. Passed and slowed down after completing pass	5	1

	Accidents	
	Non-Fatal	Fatal
i. Noticed overtaking vehicle, pulled back in lane and struck vehicle he wanted to pass	19	
j. Tried to pass before vehicle had moved over far enough	6	
k. Crowded vehicle he was passing off on berm	4	
l. Noticed exit while passing, hit brakes and swerved into vehicle he was passing	2	
m. Cut in too sharply after passing, ran off road	1	1
n. Noticed passing vehicle while starting to pass, pulled back in and ran off road	3	
o. Vehicle following for some distance in fast lane, speeded up when preceding vehicle started to pass vehicle in front	2	
p. Cut from fast lane to slow lane for exit in front of oncoming vehicle	1	
q. Came up fast in passing lane and struck vehicle already passing	5	
r. Spun out of control while trying to pass at high speed on wet road	1	
s. Tried to pass plow in middle of road, ran off road	1	
t. Failed to see if vehicle would clear objects he was passing	1	
3. Being Passed	125	4
a. Pulled out in front of passing vehicle	112	1
b. Pulled out from berm into vehicle path	6	3
c. Noticed passing vehicle, hit brakes and swerved into passing vehicle	1	
d. Vehicle being passed drifted over center line forcing passing vehicle off road	6	

	Accidents	
	Non-Fatal	Fatal
4. Slowing Up on Highway	9	0
a. Slowed down suddenly, reason unknown	4	
b. Slowed down suddenly because of congestion ahead (previous accident)	4	
c. Slowed down almost to a stop because of ice, got hit in rear	1	
5. Parking on Highway	65	2
a. Parked on road to let motor cool	1	
b. Stopped on highway to pick up wife who was in service station	1	
c. Stopped on road to clean windshield	1	
d. Cindering truck parked partly on highway to raise bed	1	
e. Stalled on highway	14	
f. Stopped on highway to help cars on berm	5	
g. Stopped on highway to check motor trouble	1	
h. Stopped on highway, reason unknown	25	1
i. Parked partly on highway to fix flat	2	
j. Stopped on highway when discovered going in wrong direction	1	1
k. Stopped on highway, nurse wanted to aid accident victims on other side	1	
l. Stopped on highway when noticed he was past exit	1	
m. Stopped on highway when flagged by cop, misunderstood signal	2	
n. Stopped in tunnel to fix flat	2	
o. Stopped on highway at exit to see where he was, hit in rear	1	
p. Stopped in tunnel, reason unknown	1	

	Accidents	
	Non-Fatal	Fatal
q. Patrons stopped at scene of accident and congested area	1	
r. Stopped on highway to check tire after skidding around	1	
s. Stepped out of car when vehicle sliding toward him — sliding vehicle struck operator and open door	1	
t. Stopped on highway to put on chains	1	
u. Didn't check to see if off road when snow made berm indeterminate — parked on highway	1	
6. Parking	21	1
a. Entered berm at high speed to park and slid out of control	2	
b. Failed to set brakes properly, vehicle rolled into parked vehicle	16	1
c. Failed to set air brakes on —put truck in gear while parked	3	
7. Backing Up on Highway	23	0
a. Backed up on interchange ramp when found he was going in the wrong direction	1	
b. Backed up on highway	3	
c. Grazed vehicle while backing out of parking place	1	
d. Backed into vehicle parked in lot	1	
e. Failed to check to rear before backing, struck object in rear	17	
8. U Turns	41	0
a. Made legal U turn in front of oncoming car	15	
b. Making illegal U turn on turnpike	26	
9. Leaving Highway	8	2
a. Going around exit ramp at high speed—lost control	5	1
b. Decided to stop at restaurant at last minute, entered at high speed and lost control	3	1
10. Throwing Cigarettes	2	0
a. Dumped cigarette ashes on seat, caught fire	1	
b. Threw cigarette into truck, caused fire	1	
11. Improper Signalling	9	0
a. Men working in tunnel not posted, sudden stops and rear ends	3	
b. Improper signalling by flagman—U turn vehicle hit by vehicle	2	
c. Men working zone not posted on main highway	4	
12. Pedestrians	2	2
a. Walked into side of moving car (service station)	1	
b. Pedestrian walking on highway	1	2
13. Miscellaneous	49	3
a. Failed to heed men working signs	1	
b. Failed to slow down when noticed congestion ahead	11	
c. Failed to heed fuzes and flagman	3	
d. Traveling at high speed through heavy traffic	1	
e. Following too close, front vehicle slowed, rear vehicle hit brakes	27	2
f. Thought he *had* to travel at 70, lost control on curve	2	
g. Traveling too fast for icy conditions, couldn't stop when in emergency	1	1
h. Tried to take turn at high speed while gravel on road, ran off	1	
i. Failed to check if trailer properly fastened to cab	1	
j. Failed to check tires—fire resulted from riding on soft tire long way	1	

	Accidents Non-Fatal	Accidents Fatal
III. Inattention (242)		
A. ASLEEP	169	6
a. Dozed off and ran off road	81	1
b. Dozed off and ran into vehicle	88	5
B. ATTENDING TO OTHER TASKS	62	2
1. Reaching for objects	13	1
a. Reached to dial radio and ran off road	2	1
b. Reached to close door and struck another vehicle	1	
c. Dropped glasses while cleaning them reached to pick up	1	
d. Reached for toll ticket and took foot off brake, rolled into vehicle	1	
e. Reached down to fix a wire, ran off road	1	
f. Ran into rear of vehicle while reaching down to switch gas tanks	1	
g. Hit vehicle in rear while pushing sleeping occupant to his own side	1	
h. Ran off road while reaching for air vent	1	
i. Ran off road while reaching to turn on windshield wipers	1	
j. Ran off road while placing hat on rear seat	1	
k. Reached in back seat for pack of cigarettes	1	
l. Dropped cigarettes on floor and reached to pick up, ran into vehicle	1	
2. Looking in Directions Other than Ahead (Connected with Driving Task)	12	0
a. Looked in mirror and came up on rear of vehicle	9	
b. Looking at gauges, looked up to see vehicle ahead	2	
c. Looked around to see if rear was clear, ran into vehicle rear	1	
3. Looking in Directions Other than Ahead (Not Connected with Driving Task)	33	0
a. Looking in wallet for toll fare, ran off road	3	
b. Looked at occupant and ran off road	4	
c. Geologist studying rock formation in cut, struck vehicle in rear	1	
d. Looking at map, lost control	2	
e. Disposing of tissue and ran off road	1	
f. Took eyes off road and suddenly saw line of cars ahead	3	
g. Looked aside for a moment and ran off road	3	
h. Trying to locate missing motor trouble, ran off road	3	
i. Looking at vehicle on other side, slowed and blocked road	1	
j. Looked at vehicle on berm, ran into rear of vehicle in front	1	
k. Looking for toll ticket and hit vehicle in rear	1	
l. Looking in station parking lot for buddies, ran into rear	1	
m. Looking around for buddies to flag them, hit vehicle in rear	1	
n. Showing occupant the toll ticket, ran off road	1	
o. Looking for toll ticket and ran off road	1	
p. Looking at restaurant and ran off road	1	

	Accidents	
	Non-Fatal	Fatal
q. Looking at accident on other side, slowed down, struck by other vehicle doing same	2	
r. Lit match to look at speedometer, ran off road	1	
s. Looking in rear of vehicle to see if cigarette flipped out, came back in	1	
t. Checking odometer for mileage, ran into vehicle	1	
4. Miscellaneous	4	1
a. Loving while driving on wet highway, lost control	1	
b. Ran off road while lighting cigarette	1	
c. Yelling at driver of vehicle he was passing, ran into vehicle	1	
d. Lost control while occupied with bee which blew in car	1	
e. Lost control while trying to close door		1
C. ILLNESS	2	1
1. Heart Attacks		
a. Suffered fatal heart attack while driving		1
b. Suffered heart attack while driving	1	
2. Epileptic Seizure		
a. Suffered epileptic seizure while driving	1	
IV. Vehicular Failures (233)		
A. BLOWOUTS	76	1
1. Fires	10	0
a. Tire blew out, truck caught fire from riding on remaining tire	2	
b. Tire blew out, car pulled to right and caught fire when hit guard rail	1	
c. Tire blew out and caught fire a short time later	7	
2. Collisions	66	1
a. Tire blew out, lost control	64	1
b. Tire blew out and car to rear swerved to avoid collision and lost control	1	
c. Tire blew out and following vehicles bunched up and collided avoiding blow-out vehicle	1	
B. SOFT TIRES	8	0
1. Fires		
a. Riding on soft tire which caught fire	4	
b. Pulled over and parked because of flat, tire caught fire	3	
c. Riding on one flat which rubbed against remaining tire, caught fire	1	
C. STRUCTURAL FAILURES	121	0
1. Brakes	29	0
a. Brakes locked and pulled vehicle into lamp post	1	
b. Brakes failed	15	
c. Brake air hose broke, brakes set and vehicle was hit in rear	2	
d. Broken diaphragm in air tank, no brakes	1	
e. Defective brakes	2	
f. Tried to stop but air pressure was low, brakes wouldn't hold	1	
g. Electric brakes locked and trailer overturned	2	
h. Fire resulting from friction from stuck brakes	3	
i. Air leak in brake system, parked vehicle rolled into vehicle	2	
2. Miscellaneous	92	0
a. Bumper let loose and interfered with steering	3	
b. Wiring caught fire	9	
c. Radius rod snapped, unable to steer	2	
d. Steering mechanism failed	6	
e. Wheel came off	12	

	Accidents	
	Non-Fatal	Fatal
f. Towing hitch broke	4	
g. Trailer wheels came loose, started weaving and lost control	1	
h. Windshield wipers failed, struck vehicle when visibility impaired	2	
i. Defective tow-bar, trailer began weaving	4	
j. Fire — cause unknown (gas leaking on muffler, someone flipped cigarette)	25	
k. Tail light not working, got hit in rear	2	
l. Generator failed, no light, vehicle coming up swerved to avoid collision, lost control	1	
m. Dolly wheels fell off, were struck by car	2	
n. Rear wheels locked and driver lost control	2	
o. Fire resulting from faulty exhaust system	4	
p. Tie rod broke and dug in ground, vehicle went out of control	2	
q. Front spring broke, vehicle went into another vehicle out of control	1	
r. Stabilizer gave way, vehicle went out of control	1	
s. Trailer wheel rubbed against frame, started fire	1	
t. Hood sprang open—blocked vision and operator ran off road	2	
u. Mechanical failure, unknown	2	
v. Trailer whipped and went out of control when drive-shaft broke	1	
w. Fire — defective wheel bearing	2	
x. Engine blew up	1	
D. IMPROPER LOADING	8	0
a. Load top heavy, trailer turned over	3	

	Accidents	
	Non-Fatal	Fatal
b. Fire resulting from load being of reacting chemical nature	1	
c. Load shifted, trailer overturned	4	
E. VEHICLE DESIGN	19	0
a. House trailer started weaving, went out of control	19	

V. Deficiencies In Routine Driving Skills (183)

1. Accelerating	5	0
a. Tramped on gas on icy highway and skidded out of control	3	
b. Tramped on gas on wet highway and skidded out of control	1	
c. Hit gas to avoid vehicle coming up from rear, spun and blocked road	1	
2. Going Around Curve	7	1
a. Cut wheels sharply on curve on wet road, went off road	2	1
b. Tried to slow down while making curve, skidded out of control	1	
c. Lost control while going around a curve	3	
d. Turned too sharply and spun around	1	
3. Passing	44	5
a. Ran into medial while passing and lost control	30	5
b. Side swiped gas attendant while passing a car at pumps	1	
c. Side swiped car while passing	9	
d. Started to pass, changed mind, skidded out of control cutting back to slow lane	2	
e. Side swiped a car while going between two cars in parking lot	2	

	Accidents Non-Fatal	Accidents Fatal
4. Being Passed	4	0
a. Became excited by passing truck and ran off road	2	
b. Pulled too far to right to let passing vehicle by—lost control in berm	2	
5. Slowing	20	1
a. Slammed on brakes on icy highway and lost control	8	1
b. Applied brakes hard on wet highway	3	
c. Tried to slow down, became excited and hit accelerator instead of brake	2	
d. Applied brakes and trailer momentum forced car off road	2	
e. Tried to slow down, ran off road and lost control	3	
f. Became nervous on icy road, hit brakes, skidded	1	
g. Applied brakes hard and skidded out of control	1	
6. Backing Up	6	0
a. Misjudged distance while backing up in parking lot, hit parked vehicle	3	
b. Got in wrong lane leaving toll booth, backed up and caught toll collector with door	1	
c. Misjudged "fifth" wheel and upset trailer	2	
7. Mainline Driving—Antecedent Behavior Unknown or Exclusive of Above	87	3
a. Ran into medial strip and lost control	21	3
b. Ran off onto berm and lost control	62	
c. Became excited on icy road and lost control	1	
d. Struck concrete divider at tunnel exit	1	
e. Cut wheels wrong way in skid, spun out of control	1	

	Accidents Non-Fatal	Accidents Fatal
f. Became excited when wind caused vehicle to sway, overcontrolled, lost control	1	

VI. Misperception

(142)

	Accidents Non-Fatal	Accidents Fatal
A. AMBIGUITY OF CLUES	7	0
a. Thought he was on lane leading to station, wasn't and ran off road	1	
b. Pulled behind lighted parked trailer thinking it was road traffic lane	1	
c. Saw car going down lane to station, thought it was highway	1	
d. Struck lighted parked car—oncoming headlights confused him, thought he was on road	1	
e. Saw army convoy parked with flares, swung into path of oncoming vehicle, thought convoy was traffic	1	
f. Confused by service station lights and ramp, cut to left off road to avoid parked trailer	1	
g. Confused by bridge—didn't know what it was in fog, hit brakes and skidded	1	
B. REDUCED VISIBILITY	49	2
1. Splashed Windshield	16	0
a. Struck vehicle or ran off road when windshield splattered with slush from passing vehicle	7	
b. Lost control when passing truck blew loose snow up on windshield	3	
c. Ran off road when windshield splattered with muddy water and high beams of vehicle	1	
d. Water splashed on windshield and sun glare obscured vision	1	

	Accidents	
	Non-Fatal	Fatal
e. Water splashed on windshield	4	
2. Weather	13	2
a. Came on foggy patch, came out and saw vehicle ahead, hit rear	1	
b. Struck vehicle in rear where vision obscured by rain	1	
c. Ran off road in heavy fog pocket	1	
d. Came upon slower moving vehicle in fog	7	2
e. Ran off road when heavy rain obscured vision	1	
f. Ran into rear of vehicle when heavy snow fall obscured vision	1	
g. Rain plus lights of opposing car, straddled curb leading to station	1	
3. Glare	15	0
a. Blinded by high beams on oncoming car, lost control	11	
b. Sun glare from hood, ran into medial strip	1	
c. Failed to see overtaking vehicle because of sun glare	1	
d. Setting sun blinded driver, ran into vehicle	1	
e. Glare from station lights on wet night, couldn't determine entrance to station	1	
4. Miscellaneous	5	0
a. Slammed on brakes and blocked road when cinder dust was raised by truck	1	
b. Eyes failed to adapt quickly enough — struck vehicle in rear in tunnel	1	
c. Windshield fogged up in tunnel—stopped and blocked road	1	
d. Came upon slower moving vehicle when using low beams	1	
e. Ran off road when windows steamed up	1	
C. DISTANCE AND RATE OF CLOSURE	84	0
1. Passing	49	0
a. Misjudged distance of vehicle ahead while starting to pass	47	
b. Pulled out in front of vehicle, thought it was further back	2	
2. Parking	8	0
a. Struck vehicle in toll booth, thought it was moving	4	
b. Struck vehicle in toll booth, misjudged stopping distance	2	
c. Tried to park behind and hit vehicle, didn't realize so close	2	
3. Miscellaneous	27	0
a. Struck moving vehicle in rear—thought it was parked	4	
b. Vehicle in front slowed, was struck when distance misjudged	5	
c. Applied brakes too late and struck slower vehicle in rear	5	
d. Entered deceleration lane and ran off road, misjudged distance ahead	2	
e. Thought vehicles were moving, applied brakes too late when discovered they were stopped	6	
f. Misjudged speed of vehicle ahead, struck in rear	5	
VII. Failure to Avoid Objects In Road (72)		
1. Animals	56	0
a. Struck a deer in roadway	42	
b. Lost control while swerving to avoid a dog	2	
c. Pheasant flew through windshield	3	
d. Ran off road while swerving to avoid a skunk	1	

	Accidents	
	Non-Fatal	Fatal
e. Swerved to avoid a rabbit and ran off road	2	
f. Swerved off road to avoid dead deer lying in road	1	
g. Struck rear of suddenly stopped vehicle which had struck a deer	1	
h. Struck steer in road	1	
i. Lost control and ran off road avoiding a deer	1	
j. Struck a herd of pigs in road	1	
k. Struck dog in road	1	
2. *Rocks*	10	0
a. Struck rock which fell in front of vehicle	3	
b. Struck a rock lying in road	5	
c. Struck vehicle while swerving to avoid rocks in road	1	
d. Ran off road while swerv- to avoid rocks in road	1	
3. *Wheels and Tires*	3	0
a. Struck a wheel lying in road	1	
b. Ran off road while swerving to avoid inner tube	1	
c. Struck a tire lying in road	1	
4. *Signs*	2	0
a. Struck warning sign which wind blew onto highway	1	
b. Struck construction sign in middle of road, no warning	1	
5. *Boxes*	1	0
a. Stopped because of boxes in road and got hit in rear	1	
VIII. Intoxicants (18)		
1. *Intoxication*		
a. Driving while intoxicated	17	1
IX. Miscellaneous (6)		
1. Attempted to land an airplane on Turnpike, landed on truck	1	
2. Accidentally hit door handle while sleeping, fell out of car	3	
3. Accidentally released brakes while sleeping in parked vehicle, rolled down bank	1	
4. Ran off road when overcome by carbon monoxide	1	

It might be helpful, in order to get a more complete understanding of highway accident causation, to discuss each of the major areas of casual factors in turn.

Each area will be discussed in general terms and will then be outlined in terms of a point of view toward accident causation. To summarize briefly, this point of view emphasizes that accidents are the result of interactions between environmental, vehicular, and human factors. Environmental, vehicular, and human factors serve as sources of cues for a driver who constantly responds to this changing complex of cues. Driving may be viewed as a task wherein environmental cues, the driver's motivations and his driving habits all interact—and he responds to these interactions. Each response in turn changes the relationship between driver, vehicle, and environment and results in new information to which the driver makes new responses in the form of decisions and muscle reactions.

Responses of driver and vehicle require what are termed environmental supports as, for example, when a driver runs off the road into a soft berm or medial strip. In this case steering is made more difficult by the lack of environmental support for wheels to turn. Slippery roadways, or very sharp turns fail to provide environmental support for certain driving maneuvers above certain speeds.

The outline presented for each category will include those environmental, vehicular and human conditions believed to be related to the type of accident under consideration. These conditions are listed for both the time *antecedent* to the accident and the time at which the accident was *precipitated*. Antecedent factors may be viewed as the history of events leading up to a set of circumstances which make an accident almost inevitable. Precipitating factors may be viewed as the set of circumstances themselves.

Any behavior pattern or task can be rather completely described when information is available about each of the following factors or variables:

1. Decisions: on the part of the driver in relation to combinations of environmental, vehicular, and human conditions.

2. Discriminations: which the driver made (failed to make) in relation to the combinations mentioned above.

3. Motivation: motivational factors of pertinence.

4. Habits: important behavior patterns which the driver has learned through experience and practice.

5. Physiological: physiological conditions of importance.

These outlines are utilized to organize data into systematic form within a sound theoretical framework. Possibly not so obvious (since remedial considerations are not of pertinence in this report) is the fact that these data are organized in a form lending itself readily to remedial considerations.

The analyses which follow are arranged in the order of their importance; importance being defined in terms of the number of accidents represented by each of the categories.

ANALYSIS OF FAILURE TO COPE WITH ROAD CONDITIONS The 686 accidents grouped in this category accounted for 22.0% of all Turnpike accidents in the 1952-1953 period studied. Most of these accidents are skidding accidents. Information describing *how* the vehicle got into the skid was lacking in most cases. Typical driver statements were:

a. "I was traveling west when all of a sudden I skidded on the icy highway and lost control."

b. "All of a sudden I skidded on the wet highway and lost control."

c. "I hit an icy spot and lost control."

d. "I spun around on the snowy highway and got hit."

Ice and snow spots are encountered with some frequency on the Turnpike during the winter season. In many cases the entire road can be in perfect condition except for a few icy or wet spots in the mountain and bridge areas. Some drivers can understandably be surprised when they suddenly notice a slippery area ahead. The degree of surprise, naturally, will be a function of how familiar they are with Turnpike conditions.

When an icy spot is suddenly encountered a driver's first reaction may be to slow down quickly or change direction to miss the spot rather than "ride it out." If this process happens to occur on the icy or wet spot a skid is quite likely.

The problem confronting a driver operating his vehicle on a completely wet, snowy or icy roadway is somewhat different. In these cases the driver is aware of conditions. He realizes he is on snow (ice, water) and adjusts his driving behavior accordingly. Speed data (described elsewhere in this report) indicates drivers tend to travel about 10 miles an hour slower on ice and snow than they do on dry road; on wet roads speed remains about the same as on dry roads. Whether or not these speed adjustments are sufficient cannot be definitely stated until adequate criteria of "safe speed for conditions" have been more precisely defined. If the frequency of accidents occurring under adverse road conditions is the yardstick, however, one would be inclined to judge that further adjustment in speed is necessary, or that greater driver ability must be developed.

Why is it that some drivers insist on speeds beyond their ability? Probably many factors are involved here. First, a driver found on the Turnpike under adverse conditions usually has a definite destination and a specific purpose in going there. He is certainly not merely admiring the scenery. Driving under adverse road conditions is hardly pleasant to the driver who wants to complete this task as quickly as possible. Thus, the very conditions making the task difficult also serve to generate impatience.

Second, drivers tend to overestimate their driving ability. This attitude is given nourishment from two sources:

(1) Clear-cut definitions of just what conditions can and cannot be handled even by "good" drivers are lacking. Thus drivers have no criteria against which to judge their behavior.

(2) Each mile driven safely under adverse conditions serves to increase the immodest respect for his own ability inherent to the driver. Some, of course, are eventually jolted from their complacency by an accident, but this is of little value if our point of view is one of preventive medicine rather than survival of the fittest.

To this point the emphasis has been on the speeds driven under adverse conditions. This is apt to be misleading, for speed in and of itself does not "cause" the skid. Driving errors tend to become magnified, however, as speed increases. Negotiating a curve poorly or slowing down suddenly might be unimportant at low speed but could be disastrous at higher speeds. Skids are probably precipitated in this manner although additional data should be gathered in this area.

It would seem, then, that this class of accidents basically can be attributed to deficiencies in driving skills and techniques. The following evidence serves to support this view.

The behaviors listed under Deficiencies in Routine Driving Skills (Table II-1) are those that precipitated skids under similar conditions to those listed for this category. These behaviors can obviously be described as deficiencies in routine driving skills. The skidding accidents listed as Failure to Cope With Road Conditions accidents would probably be included in the Deficiencies in Routine Driving Skills category were sufficient information regarding what the driver did or did not do included in the accident reports for these accidents.

Further than this, statistical analysis of our data indicates a greater percentage of females (as compared to males) are the drivers of vehicles in this category (Failure to Cope With Road Conditions) than we would expect from the percentage of female drivers involved in other classes of accidents. The same can be said of female drivers in Deficiencies in Routine Driving Skills. These similar disparities could be attributed to the basic similarities in the types of accidents.

The obvious implication of the above is that females are not as proficient in handling a vehicle in conditions related to these types of accidents. Such a conclusion seems tenable in view of the following reasoning.

Driving tests used in the licensing procedure do not require that applicants demonstrate proficiency in handling a vehicle in adverse conditions. So far as can be determined not one state requires a driver to demonstrate proficiency on icy roads, in handling a blowout or other emergency situation or, for that matter, to demonstrate ability in handling a vehicle under conditions of higher speed travel. Thus drivers are licensed and then learn these abilities.

To consider skidding accidents specifically, any driver's first skid must occur after he has been legally granted the privilege to drive. Thus all drivers are beginners when it comes to skidding. Their proficiency in this area increases (or decreases) as a function of how often they drive under conditions conducive to skidding, and how accurate is their knowledge of what to do under such conditions. Poor habits obviously can be learned well in this case just as can good habits.

The female driver, by the nature of her role in our culture, does not experience poor driving conditions as much as does her male counterpart. Males must travel to work whereas many female drivers are housewives. Usually a male does the driving when escorting his lady and so on. Other evidence could be offered but, in general, it seems that males compile more driving experience under adverse road conditions. Thus it is that female drivers are somewhat restricted from learning what to do in a skid by comparatively less experience, the only teacher. It is not surprising to find them disproportionately high in this category nor in Deficiencies in Routine Driving Skills for that matter.

To complete this story it should be remembered that our statistics indicate female drivers are more "prone" to skidding accidents than males; nevertheless, male drivers still account for 78% of all skidding accidents undoubtedly because of the high number of vehicle miles driven by males as compared to females.

There are three major points in summary:

(1) Accidents grouped in this category would probably be found in Deficiencies in Routine Driving Skills were sufficient information available.

(2) Violations of safe procedures probably account for many of these accidents. These violations can be attributed to lack of knowledge of what is dangerous and poor attitudes in the form of overestimation of ability to cope with the situation.

(3) The lack of training in these situations and the lack of sound driver selection based on proficiency under various conditions, are two of the major factors contributing to these accidents.

The following outline expands these views more fully. In the left hand column are conditions which lead up to accidents of this type; in the right hand column are the conditions which precipitate, or "trigger", the accident.

ANTECEDENT

A. Environmental factors related to:

1. Reduced traction
    - a. Snowy, icy, wet road surface
    - b. Temperature differences at bridges resulting in frosty, icy, wet spots
2. Reduced visibility
    - a. Snowing, raining, hailing, sleeting
3. Related symbolic environment
    - a. Signs before bridges reducing speed limit
    - b. Radio reports
    - c. Toll booth operator's warnings

B. Vehicular Factors:

1. Tire condition — reduced traction when poor (bald)

PRECIPITATING

A. Environmental factors related to:

1. Precipitating skid
    - a. Curve in road
    - b. Uneven road surface
    - c. Object in road
    - d. Tar ridges between pavement blocks
    - e. Edge of road indeterminate because of snow
    - f. Piles of slush, snow, or ice; or ruts in snow or slush or ice

ANTECEDENT	PRECIPITATING
2. Speedometer reading indicates a speed high for conditions	
3. Weight distribution (related to location of center of gravity of vehicle and the effect on maneuverability of vehicle)	
4. Chains or snow-tread tires (lack of)	
C. *Human Factors:*	
1. Discriminations a. Road conditions b. Weather condition c. Symbolic environment (anticipatory responses) d. Tire condition e. Propensity of vehicle to skid f. Speedometer reading	1. Discriminations a. Loss of traction b. Change in vehicle's attitude in relation to road c. Failure to detect path of least probable collision
2. Decisions a. Travel rather than stay home b. Failure to reduce to "safe" speed for conditions c. Erratic and abrupt changes in direction d. Failure to use chains (snow treads) e. Failure to replace worn (bald) tires	2. Decisions a. Failure to select path with least probability of collisions
3. Motor Responses a. (Failure to) decrease pressure on accelerator b. (Failure to exhibit) smooth control movements; coordinated turns; coordinated brake, accelerator, steering manipulation	3. Motor Responses a. (Failure to) turn steering in direction of skid b. (Failure to exhibit) smooth control manipulation 1. Abrupt slamming on of brakes
4. Motivation a. Test limits of ability (don't need chains, etc.) b. Overestimation of ability to cope with skids, stops on ice, etc.	

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ANTECEDENT	PRECIPITATING
c. Social facilitation — other vehicles "getting away" with traveling at unsafe speeds	
d. Reinforcement of idea that higher speeds are safe as a function of how long higher speed operation is uninterrupted by a skid or other danger.	
5. Habits	5. Habits a. Put on brakes abruptly when in trouble b. Turn abruptly away from approaching danger
D. Environmental Supports:	***D. Environmental Supports:*** a. Lack of traction on slippery surface

ANALYSIS OF ILLEGAL AND UNSAFE ACTIONS Accidents in this category accounted for 21.5% of the total. The precipitating factor *primarily* consists of a violation of a safe driving procedure, i.e., violations of safety and legal codes. There is overlapping between this area and Deficiencies in Routine Driving Skills. The latter category involves the violation of procedures in some cases also, but *primary* responsibility was judged to lie in manipulative ability. Manipulative ability may also be involved in many cases in the present category, but *primary* responsibility for the accident is assigned to the violation of a procedure. Violations included pulling out into the passing lane without first checking for other vehicles in that lane, stopping on the main traveled portion of the highway, making U-turns (illegal on the Turnpike), passing on the right, etc. Typical driver statements were:

a. "I stopped on the highway to clean my windshield and this car came along and hit me."

b. "The car ahead started to slow down for the exit. I guess I was too close to him because I couldn't get stopped in time."

Driving experience of the drivers found in this category is extensive. Almost two-thirds of these people had at least ten years of driving experience. Thus, it is extremely doubtful that ignorance of safe procedures was a rule for this group. It is more likely that these drivers had developed too much security in the driving task. The practices of giving signals, checking for other vehicles, following too closely, and checking to see if a vehicle is properly parked were probably considered to be relatively unimportant and were forgotten for the moment.

In general, even if such violations are considered potentially dangerous, an experienced driver may tend to overestimate his ability in coping with possible emergencies.

Enforcement procedures could contribute to the development of a healthier attitude here. Instead of placing enforcement emphasis upon speed in a majority of cases (as does most publicity regarding accidents), more of the emphasis should be placed on the procedures whose violation, at any speed, leads to accidents.

Ignorance of codes does merit consideration in this category. The nature of the Turnpike makes the following of certain procedures more important on this road than on others. For example, U-turns are illegal on the Turnpike. The high speed travel for which the Turnpike was designed makes such turns extremely hazardous and procedures for alerting the driver to this fact are worthy of further consideration.

Possible driver unawareness of another type should be mentioned here. In a few accidents the precipitating factor seems to consist of violation of a safe procedure in the vicinity of accidents or maintenance. This violation consists of a failure to post sufficient warning of an accident or repairs ahead, i.e., a failure to acquaint oncoming drivers of conditions at a sufficient distance preceding the area to enable the drivers to make allowances for the situation ahead. While the number of accidents precipitated by such factors is minor compared to the total, it is felt some attention should be given to the proper warning distance in given areas, and the most efficient way to acquaint drivers with conditions they will shortly encounter. Such considerations would apply to warning drivers of icy spots as well as to those conditions discussed above.

In summary, human factors of most importance for this category deal with the tendency to neglect the practice of many safety and legal procedures. This tendency is most facilitated by the over-confidence born of long driving experience and, to a lesser degree, by ignorance or unawareness of the procedures per se.

The following outline expands these views more fully. In the left hand column are conditions which lead up to accidents of this type; in the right hand column are the conditions which precipitate, or "trigger", the accident.

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors contributing to traffic density:	
a. Dry road	
b. Clear weather	
c. Daylight	
d. Turnpike engineering — superhighway	
B. Vehicular Factors	
1. Factors related to stopping on highway:	
a. Vehicle condition	

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ANTECEDENT	PRECIPITATING
2. Factors related to improper attitudes of superiority or fear: a. Vehicle size b. Vehicle noise c. Vehicle speed	
C. Human Factors	
1. Decisions: a. (Failure to) follow *SOP's of road 1. (Failure to) predict consequences of actions 2. Momentary forgetfulness	1. Decisions: a. Change lanes to pass without checking rear b. Park stalled auto on highway c. Pass before lane clear d. Slow suddenly e. Tailgating f. Pass when vision obscured g. Failure to check that brakes are set and vehicle is in gear when parking
2. Discriminations: a. Proximity of other traffic 1. Consequences of actions	
3. Motor responses: a. Responses involved in car manipulation 1. Acceleration, deceleration 2. Changing direction 3. Parking procedures	3. Motor responses: a. Failure to: 1. Check for passing vehicles 2. Check for vehicles in rear 3. Set brakes, put vehicles in gear
4. Motivation: a. Overestimate ability b. Test limits of environment c. Assume others will not deviate from "normal" routines	4. Motivation: a. Pleasures in future (coffee stop) tend to make operator negligent in immediate actions (parking vehicle properly)
5. Habits	5. Habits: a. Slam on brakes when in danger
D. Environmental Supports	
1. Soft berm or medial 2. Gravel on road	

**Safe Operating Procedures*

ANALYSIS OF INATTENTIVENESS This category accounted for 17.2% of the accidents considered. Two major breakdowns are contained in this category and are discussed below.

1. *Asleep*

Drivers falling asleep accounted for 13.2% of all accidents considered. Typical driver statements were:

a. "I must have dozed off and I ran off the road."

b. "I guess I fell asleep and when I woke up there was this truck in front of me."

Qualitatively considered, this class of accidents seems to consist of two general types of "sleep". There are those drivers who apparently fall asleep due to physical exhaustion and there are those who are lulled into a state which might be termed psychological fatigue. These latter seem to be awake but unaware or unconcerned with their role as a driver traveling over a highway. Whether these constitute separate and distinct classes of accidents is doubted. More likely they are merely points along a continuum.

The former class possibly consists of drivers who embarked on their trip in a physically tired state. These people were affected by various monotony-inducing factors but contributed much more to the likelihood of an accident by a lack of sleep preceding the trip. Physically exhausted, these people needed sleep prior to their trip much more than distraction while on the trip to keep them awake. Officers list the amount of sleep drivers in this category enjoyed prior to the trip on which they fell asleep, but all things considered, the reliability of these figures is questionable. In many cases the officer disagrees with the driver's statement on the evidence presented by the driver's appearance, i.e., red rimmed eyes, blood-shot eyes, and so on. Lacking data regarding a driver's physical state it is impossible to judge how many of these people fell asleep mainly because they were tired.

The latter type of "sleep" (or extreme inattentiveness) may be attributed to an interaction of a number of factors: boredom, "ideal" environment (no intersections, traffic lights, etc.), evenly spaced delineators which at night reflect headlights with monotonous regularity, cramped bodily position of the driver, etc.

It is to be noted that an unusual proportion of "falling asleep" accidents happen to drivers in the 16-25 year age group. It might be added that this is the age group selected for military service. Many of the drivers involved in this class of accident were servicemen hurrying back to or from camp on limited leave time. In such instances we should not expect the driver to be in well rested condition. Further consideration is given this point later in this chapter.

To outline this analysis:

ANTECEDENT	**PRECIPITATING**
A. Environmental Factors	
1. Factors contributing to monotony:	(Asleep accidents are set up by Antecedent Factors primarily)
a. Evenly spaced delineators	
b. Evenly spaced pavement block separations	
c. Uniform roadway texture	
d. Remoteness of surrounding environment (distance)	

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ANTECEDENT **PRECIPITATING**

- e. Absence of red lights, intersections, etc.
- f. Relatively low traffic density
- g. "Ideal" weather and visibility conditions
- h. Percentage of straight road and curves engineered for ease of driving.
- i. Length of trip possible (327 miles)

B. *Vehicular Factors*

1. Factors contributing to monotony:
    - a. Uniform engine hum
    - b. Smooth comfortable ride of new cars
    - c. Ease of manipulation
    - d. Heating system
    - e. Seat installation (relation to ease of breathing, circulation and digestion

C. *Human Factors*

1. Discriminations
    - a. Drowsy state
2. Decisions
    - a. Stop and stretch
    - b. (Do not) keep vehicle ventilated and not too warm
    - c. (Do not) attempt too great a distance without stop
    - d. Few decisions to make insofar as manipulation of vehicle is concerned
    - e. (Avoid) heavy meals while driving long distances
3. Motor Responses
    - a. (Failure to) shift position to facilitate circulation, digestion, respiration
    - b. "Broken" or "Varied" scanning

ANTECEDENT

4. Motivation
   a. Desire to reach destination quickly
      1. Driving task contains little reward in and of itself
      2. A "rest and stretch" stop would waste time
      3. Occupational
   b. Overestimation of ability to stay awake
      1. After short sleep night (day) before trip, drinking parties, etc.
   c. Desire to remain warm (comfortable) no ventilation in winter
5. Habits
   a. Slouch in and maintain most comfortable position

PRECIPITATING

ATTENDING TO OTHER TASKS This class of accident accounts for 4.0% of all accidents surveyed. Accidents listed here were precipitated by drivers' inattention to the road ahead. This inattention may be the result of attention to some task not connected with driving, or to a driving sub-task which momentarily diverts attention from the road ahead. Typical driver statements include:

a. "I was reaching toward the back seat to get a pack of cigarettes when all of a sudden I ran off the road and upset".

b. "I was looking in my mirror when I came up on the rear of this other car. It was too late to stop".

It is not surprising to find most drivers in this category have had considerable driving experience. As discussed previously, the more automatic driving habits have become, the more likely a driver will not be as alert.

Familiarity with the road resulting from numerous trips would contribute to this sense of security and complacency.

Another factor is probably of importance. For many drivers time consists of "now". Little thought is given to projecting into the future (even just a few minutes hence) the consequences of actions "now". Consequently, a driver reaching for a cigarette or looking for his toll ticket does not consider what might happen in the course of the few moments he is occupied. He could take stock of the position of other traffic, whether or not he was approaching a curve around which might be a slow moving vehicle, and so on, since this information is available to him. When driving on a "now" basis, however, distractions seldom are viewed as time-consuming and drivers faithfully expect the status quo to remain just that. See outline on next page.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors contributing to relaxing of vigilance	1. "Appearance" of object in path at close distance (other vehicle usually)
a. Relatively "ideal" conditions	2. Cues indicating vehicle is off main highway or headed in that direction
(1) Daylight clear-cloudy, dry	
(2) Night clear-cloudy, dry	
(3) Highway engineered for ease in driving	
B. Vehicular Factors	
1. Factors contributing to relaxing of vigilance	
a. Ease of handling	
b. Comfort of vehicle	
C. Human Facrors	
1. Decisions	1. Decisions
a. Few decisions to make other than routine driving decisions	a. Best possible escape route
(1) Automatic responses born of long driving experience have eliminated need for decisions	
(2) Ideal environmental context elicits lowered vigilance, lowered discrimination, less need for decisions apparent	
2. Discriminations	2. Collision course
a. Poor scanning skill or habit	
3. Motor responses	3. Motor responses
4. Motivation	a. Hit brakes
a. Driver tends to test limits	b. Brakes—steering—accelerator coordination for best escape route
b. Driving task facilitates learning unsafe modes of response—driving often done while fatigued	

ANTECEDENT	PRECIPITATING
c. Driver's attention to driving is variable. Novice less likely to get drowsy or "inattentive"	
d. Not enough attention is given to predicting probable status of environment subsequent to an act removing attention from road ahead for momentary periods.	
e. Easily distracted by environmental cues.	

ANALYSIS OF VEHICLE FAILURES Vehicle failures accounted for 13.8% of all Turnpike accidents in the period studied. This area covers accidents caused by structural failure of the vehicle, blowouts, soft tires, improper loading, and vehicle design. In the following analysis, each of these will be considered separately.

1. *Structural failures.*

Typical driver statements for this category include the following:

a. "I was nearing my turnoff and started pumping my brakes to slow down. They wouldn't hold and I ran off onto the berm and hit the guard rail rather than hit the car ahead."

b. "All of a sudden my car pulled to the right and upset." (Officers' statement indicated that a radius rod had snapped.)

Vehicle condition is the key factor for this category. Primary responsibility for an accident was assigned to a failure of some feature of the vehicle. Unfortunately, the vehicle condition prior to the accident is not known.

A disproportionate number of trucks are found in this category as compared to the proportion of trucks involved in other types of accidents. This disparity is statistically significant. Whether this indicates trucks are in relatively poorer condition as compared to passenger cars, or whether this fact indicates trucks break down as a result of their comparatively more difficult task is not known.

In any event, vehicle failures do involve parts of the vehicle which receive heavy wear. Brake failures, steering mechanism failures and wheels coming off account for a majority of these accidents. That these are among the parts most likely to give way on long trips would appear logical.

If a human contribution can be assigned to this category, the most apparent would be negligence. Drivers are apt to take "good" vehicle condition for granted and many seldom check for other than obvious deficiencies. State inspection systems guarantee that vehicles meet certain specified criteria at inspection time but this does not assure that critical deterioration of some vehicle part could not take place in the six-month interval between inspections. Drivers are expected to assume responsibility for these intervals but expectations here probably exceed actualities.

It is possible that a given driver, well acquainted with a vehicle deficiency, will attempt to make a trip anyway in the hope that the vehicle will stand up. Economic considerations related to repair bills often temper such a decision.

It is more probable, however, that drivers are pretty much unaware of critical vehicle condition. Cars are more or less expected to go on running forever, particularly in states where inspection twice a year attests to good vehicle condition. In addition, modern vehicles reinforce the idea of their immortality. A driver expected balkiness from his vehicle in the 1920's but today's streamliners are not expected to be anything but efficient.

Then too, knowledge of vehicle factors is quite limited. The increasing utilization of autos as a means of travel and their increased complexity has led to the development of specialized mechanics. Drivers generally are not as inclined to "tinker" with their vehicles as in former days; today a driver "drives" and a mechanic "checks". This division of labor applies to trucking companies also where drivers "drive" and maintenance men "maintain".

Knowledge related to the demands of Turnpike travel is also probably meager. "Bugs" in a vehicle may not show up under routine city driving but the requirements of constant high speed operation for relatively long periods of time can induce the breakdown of parts.

In summary, the human factors of probable importance are negligence in vehicle checking and ignorance as to vehicle requirements for both local and extended travel.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors 1. Factors conducive to high speed travel: a. Dry road b. Clear-cloudy weather c. Daylight d. Curved road e. Wind gusts	
B. Vehicular Factors 1. Vehicle condition a. Brakes, steering, etc., in mediocre or poor condition b. Age of vehicle c. Degree of preventive maintenance d. Degree of abuse in handling of vehicle e. Previous accidents or breakdowns could result in weakening of some vehicle part	1. Vehicle condition a. Decreased or absent braking ability b. Decreased or absent steering ability c. Fire d. Vehicle stalls

ANTECEDENT	PRECIPITATING
C. *Human Factors*	
1. Decisions a. Failure to check vehicle condition 1. Decision to make (not make) trip with vehicle in poor condition 2. Adjust driving behavior in terms of inferior part (slower driving with poorer brakes, etc.)	1. Decisions a. Come to a stop and apply emergency measures if necessary (fire extinguishers, etc.) b. Do not stop on highway (main traveled portion)
2. Discriminations a. (Failure to) perceive differences in handling characteristics of vehicle (poor brakes slower deceleration)	2. Discriminations a. Failure of vehicle part
3. Motivation a. Overestimation of vehicle condition and underestimation of its importance 1. Feeling that so long as vehicle runs, parts are in good working order. Lack of interest in preventive maintenance. 2. Short range view that economic considerations (repair bills) of the moment can be put off indefinitely.	

2. *Blowouts.*

In this category are grouped those accidents precipitated by a blowout of one of the vehicle's tires. Statements by drivers involved in this class of accidents are typified by the following:

a. "My tire blew out as I was doing 50 m.p.h. and I lost control."

b. "My tire blew and the car pulled to the right into the guard rail."

The human factor in the blowout accident seems to fall in two major categories which we can, for convenience, term motivation and driving aptitude.

The first of these is related to conditions prior to the blowout. For example, whether or not a driver inspected his vehicle (tire) condition would primarily be motivational in nature. Whether or not he chose to take a long trip with poor tires, the speed at which he chose to travel on a hot day, the care with which he checked tire air pressure, and other related factors are motivational in nature. Data about these factors do not appear in accident reports, naturally, and the relative importance of these variables must be assumed.

There is little assumption involved in specifying the demands made of the driver once his tire has blown, however. Unless the vehicle is equipped with safety tubes, safety rims or other mechanical aids, a blowout usually results in an extreme pull to one side. If the driver lacks a good grip upon the steering wheel the battle is apt to be lost before it has begun, since the steering wheel will spin sharply and the vehicle will be out of control.

Even granting a good grip, however, a larger degree of physical strength and driver "know-how" is necessary to prevent the vehicle from going out of control. As an indication of this demand we find a disproportionate percentage of females as compared to males in this category.

Aggravating the demand on physical strength is what seems to be an almost universal response of drivers when in trouble—the tendency to slam on the brakes and come to a stop as quickly as possible. Use of the brake in this manner tends to increase the pull of the vehicle with which the driver is trying to cope.

Running off the roadway onto a soft berm or medial strip can also increase the demands on the driver. Mud, in and of itself, makes steering maneuvers difficult. When compounded by a blowout the task could become impossible.

Here again, as was mentioned in "Failure to Cope with Road Conditions", training and experience does not come through pre-licensing training, but is left to later actual occurrences.

The analysis of blowout accidents follows.

ANTECEDENT	**PRECIPITATING**
A. Environmental Factors	
1. Factors contributing to heat generation: a. Dry roadway b. Warm or hot road surface c. Sunlight d. Hot day (night)	1. Increased air pressure within tire
2. Factors contributing to weakened or "bruised" tires: a. Objects in roadway	2. Air pressure reaches critical point for weak spot in tire
3. Related symbolic environment: a. Signposts — "Slides", "Fallen Rock Zone". b. Radio reports on temperature	

ANTECEDENT	PRECIPITATING
B. *Vehicular Factors*	
1. Tire condition—reduced traction	1. Internal air pressure greater than exterior
2. Tire inflation—proper pressure	2. Portion of tire "gives"—loud bang of escaping air
3. Steering alignment — tire wear, "pull" to one side	3. Sudden "pull" to one side of unusual magnitude
4. Imperfection in tire construction	
5. Speedometer — indicates "high" speed	
6. Temperature gauge — indicates "above normal" temperature	
C. *Human Factors*	
1. Discriminations	1. Discriminations
a. Thermal — environmental temperature	a. Auditory — explosion of escaping air
b. Kinaesthetic—"pull" of steering wheel from steering misalignment, soft tire, etc.	b. Kinaesthetic — sudden pull to one side perceived through steering wheel
c. Visual—speedometer needle in "high" range —objects in roadway —temperature gauge needle —texture of road surface —symbolic environment —heat waves from road surface —tire condition from inspection	c. Visual—sudden change in direction toward road edge
d. Visual — kinaesthetic — "skidding" or "weaving" of vehicle from reduced traction (bald tire condition)	
2. Decisions	2. Decisions
a. Maintain (decrease) speed when knowledge of a combination of tire condition, road temperature indicate this may (not) be prudent	a. Come to a stop
b. (Failure to) check tire condition	b. Maintain a course on roadway
c. (Failure to) replace worn tire(s)	

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ANTECEDENT	PRECIPITATING
d. (Failure to) check wheel alignment and correct if necessary	
e. (Failure to) check tire air pressure	
3. Motor Responses	3. Motor Responses
a. (Failure to) decrease pressure on accelerator	a. Sudden extreme pressure on brakepedal
b. (Failure to) counteract pull to one side (steering misalignment) with opposite pressure on steering wheel	b. Extreme pressure on steering wheel to counteract pull to one side
c. (Failure to) have firm grip on steering wheel	
4. Motivation	4. Motivation
a. Keep vehicle in good condition	a. Reach 0 speed as quickly as possible when in danger
b. "Safety Play" vs. probability of getting by	
5. Habits	5. Habits
	a. Slam on brakes when in danger (all-or-none response)
6. Physiological	6. Physiological
a. Alertness—terms of fatigue	a. Lengthened reaction time, relaxed enforcement of procedures
b. Physical strength	b. Strength (physical) to hold steering wheel firmly and prevent going out of control
D. Environmental Supports	
a. Distance from wheel to edge of road	a. Soft berm or medial — increase pull on steering wheel

3. *Soft tire.*

Typical statements for this group include:

a. "I was traveling west and noticed another rig wave me over to the side. I pulled over and got out to check. My right rear dual caught fire a couple of minutes later. One of the tires must have gone flat and got overheated."

In essence, what is involved herein is continued driving on a soft or flat truck-tire which eventually catches fire. Judging from accident reports the driver is not aware of the soft tire condition until after the fire has occurred. Collision is not involved in this category; the accident consists merely of the fire and resulting damage to vehicle and cargo.

Probably the most important human factor for this category of accident consists in negligence in checking vehicle condition. While gas station attendants furnish excellent service in cleaning windshields and in checking oil and water, they seldom check tire air pressure as part of a routine fuel sale. Drivers generally overlook this factor also.

Once a vehicle is in motion a driver lacks information related to tire air pressure or tire temperature. The former can be judged in some cases by deviations from normal "handling" qualities of the vehicle; the latter is never distinguishable. Under present conditions then, the most propitious time to check tire conditions is while the vehicle is at a standstill.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors related to heat generation: a. Dry road b. Clear-cloudy weather c. Daylight d. Warm temperature	Heat generation to critical point for tire: (tire "catches" fire).
2. Object in road which results in "slow leak" puncture	Tire pressure steadily decreases facilitating heat generation to burning point.
B. Vehicular Factors	
1. Low tire air pressure	
2. Supporting dual tire of proper inflation	
3. Vehicle weight—contributes to generation of heat	
4. Vehicle speed—contributes to generation of heat	
5. Tire condition	
C. Human Factors	
1. Discriminations a. Differences in handling characteristics of vehicle b. Tire gauge—indicates low pressure c. Tire condition — visual inspection	
2. Decisions a. (Failure to) check tire pressure at gas stops b. (Failure to) inspect vehicle (tire) condition	
3. Motivation a. Overestimation of vehicle condition. Little enthusiasm for preventive maintenance.	

4. *Vehicle design.*

These accidents are almost identical. In each case a vehicle towing a house trailer is involved and, in each case, this trailer began weaving and finally led to the combination of vehicles going out of control. The driver typically reported that:

> "I was traveling about 45 miles per hour when, for no apparent reason, the trailer started to weave. I tried to get it under control but couldn't do it. We ran off the road and upset."

The principal human contribution for this category seems to consist of the decision to travel at speeds dangerous for this combination of vehicles. This decision could be attributed to two factors:

a. Possibly drivers are ignorant of the dangers of higher speeds for this combination of vehicles. This viewpoint would seem to be contradicted by the extensive driving experience of those drivers grouped in this category. (Although their experience in driving this type of vehicle is not necessarily extensive.)

b. It is more probable that drivers overestimate their ability to handle these vehicles and underestimate the dangers of higher speeds. Here, as in other categories, the greater the number of times a given driver has escaped an accident while "testing his luck", the greater will be his tendency to overestimate his ability in the future.

Once weaving has started drivers probably add to the likelihood of an accident by maneuvers of an overcorrecting nature. Overcorrections would not have to be of very great magnitude in view of the proneness of the vehicle combination itself to weaving.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. *Environmental Factors*	
1. Factors related to travel at higher speeds: a. Clear-cloudy weather b. Dry road c. Straight road	1. Factors related to weaving: a. Gusts of wind b. Curves
B. *Vehicular Factors*	
1. Tow connection between vehicles of unstable design 2. Lightness (weight of vehicles contributes to instability)	1. Factors related to weaving: a. Speed of vehicle b. Condition of vehicle 1. Soft tires 2. Tow connection worn 3. Worn king pins — wheel "shimmy"
C. *Human Factors*	
1. Decisions a. (Do not) travel at higher speeds b. (Do not) practice erratic steering brake, gas adjustments	1. Decisions a. (Do not) reduce speed gradually (slamming on brakes is dangerous in this situation)

ANTECEDENT	PRECIPITATING
2. Discriminations a. Speedometer — indicates speed 45 m.p.h. or above	2. Discriminations a. Handling characteristics of vehicle indicate weaving
3. Motivation a. Impatient feeling when traveling on "high speed" highway at slower speeds. Drivers tend to travel faster b. Overestimation of driving ability in emergencies c. Underestimation of dangers involved in weaving	3. Motivation a. Stop as quickly as possible when in danger
4. Habits	4. Habits a. Slam on brakes when in danger b. Quickly turn back to road when off on berm or medial

5. *Improper Loading.*

In each case included in this category, improper loading of the vehicle was judged to be the major precipitating factor in the accident. As would be expected from the nature of the precipitating factor, all vehicles in this category were trucks. Typical driver statements for this group include:

a. "I started around the curve and, as I did, the load shifted and the rig upset on me."

In all but one case shifting cargo contributed to upsetting a trailer-truck. In the remaining case faulty loading at the terminal resulted in placing two reacting chemicals in close proximity to each other. A fire resulted which destroyed the vehicle.

Incorrect loading of a vehicle probably results from at least one or a combination of the following factors:

(1) Lack of knowledge of correct loading procedures for a given cargo. The relationship between center of gravity location and vehicle stability is important. A lack of this knowledge could result in top-heavy loading of a vehicle. Similarly, lack of knowledge of the reacting nature of the chemicals forming the cargo for one of the trucks in this category could have been the reason for the incorrect placing of the cargo.

(2) Haste or carelessness on the part of loaders. Since loading is usually done by personnel other than the driver, a personal stake in vehicle stability and other safety precautions would not necessarily be present. Such carelessness could account for improperly secured loads which could shift and upset vehicle balance.

Probably the major contribution of the driver consists of negotiating a curve rather sharply (so far as the upset vehicles are concerned). These vehicles had obviously traveled some distance before overturning and probably had successfully negotiated curves in the course of that journey. Turnpike curves are engineered for high speeds and the superelevation (degree of bank) would surely be sufficient for the low speeds at which these trucks were traveling. Officer's estimates of this factor indicated 35 miles per hour as the highest speed at which any of these vehicles was traveling.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors related to upsetting	
a. Curved road	
B. Vehicular Factors	
1. Improperly secured load	1. Load shifts and vehicle is unbalanced and tips
2. Top heavy load	
3. Improperly arranged load	
C. Human Factors	
1. Decisions	1. Decisions
a. Loaders	
1. (Failure to) load vehicle with heavy cargo at bottom of load	
2. (Failure to) secure load properly	
3. (Do not) place materials potentially dangerous in close proximity	
b. Driver	b. Driver
1. (Failure to) coordinate turns well	1. Choice between trying to right vehicle and tipping over. Proximity of traffic will determine "best" escape route.
2. Discriminations	2. Discriminations
a. Handling characteristics of vehicle indicate improper loading	a. Rapid scanning to discover if possible to abruptly swing vehicle to "right" it.
3. Motivation	3. Motivation
a. Loaders-job becomes routine, wants to finish in a hurry. If loader is not driver, personal stake may not be involved.	a. Driver—avoid turning over
4. Physiological	
a. Driver—fatigued state—less coordination in driving	

ANALYSIS OF DEFICIENCIES IN ROUTINE DRIVING SKILLS Accidents precipitated by driver error in performing a routine part of the driving task accounted for 11.7% of all accidents occurring during 1952 and 1953. Driver errors included in this category are those primarily concerned with the manipulation of the vehicle, i.e., errors which can be attributed to deficiencies in perceptual—motor skills such as hand-eye coordination in negotiating a curve, smoothness of braking and so on. Not included in this category are driver errors which are primarily a matter of violation of safe or legal procedures such as following too closely, failing to give hand signals, etc. These latter violations require no special manipulative motor skill but rather entail mere observance on the part of the driver. Typical driver statements for this category include:

a. "I was going around the curve and I guess I cut my wheels too sharply and I ran off the road."

b. "I started to pass this car ahead and got over too far and ran into the medial strip. I lost control of the car and ended up against the guard rail."

c. "I wanted to get off at Irwin Interchange so I hit my brakes hard to slow down and skidded off the icy road."

Drivers in this category have less driving experience than do drivers of vehicles involved in other types of accidents. It should be noted, however, that a large number of drivers involved in this type of accident have compiled 10 or more years and more than 100,000 vehicle miles driving experience. These figures indicate that driving experience is not necessarily an index of driving ability. Poor driving habits reinforced by long years of practice do not become better. While driver training and driver selection procedures have made advances in recent years, it is still quite possible for drivers to be licensed who are not proficient behind the wheel. The behaviors precipitating accidents are, for the most part, not evaluated in any driver licensing test! It is not surprising to find drivers exhibiting deficiencies.

When for example, is a driver tested for his ability to handle a car on ice? When is he tested for his ability to drive at higher (legally permitted) speeds in the traffic density usually found under these conditions? When is his judgment of distance tested under these conditions? When is his ability to negotiate curves qualitatively appraised for smoothness and coordination of turn, particularly at speeds or on road conditions where jerky motions could precipitate a skid or lead to driver panic? And so on through a whole range of behaviors required in routine driving situations.

In Pennsylvania, for example, and about 40% of the Turnpike accidents involve Pennsylvania drivers, it is possible to obtain a license by demonstrating proficiency on a special closed course on which other traffic is never once encountered! Speeds on this course usually do not exceed thirty miles per hour, but, within a matter of minutes after demonstrating proficiency in this artificial setting, a newly licensed driver can legally attempt to negotiate congested city travel or drive at high speeds on state highways or on the Turnpike.

While the human errors apparent in Turnpike accidents should be of concern a selection procedure which permits such errors is of no less importance. Not only is a realistic analysis of the requirements of the driving task necessary but the possible differences between knowing verbally *what* to do in a situation and whether or not a driver *can* do it must be accounted for.

The following pages expands these views more fully. In the left hand column are conditions which lead up to accidents of this type: in in the right hand column are the conditions which precipitate, or "trigger," the accident.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors related to difficulty of driving task:	
a. Road conditions	
(1) Wet	
(2) Icy or snowy (Sanded, unsanded)	
(3) Icy or snowy spots (Sanded, unsanded)	
b. Weather conditions	
(1) Raining	
(2) Snowing	
(3) Hailing	
c. Visibility conditions	
(1) Day or night	
d. Road conditions	
(1) Straight	
(2) Curved (superelevation)	
e. Other traffic	
(1) Density	
(2) Speed	
B. Vehicular Factors	
1. Factors related to difficulty of driving task	
a. Vehicle type (car, truck, etc.)	
(1) Ease of handling	
(2) Stability	
b. Vehicle condition	
C. Human Factors	
1. Decisions	1. Decisions
a. (Failure to) exhibit proper combination of brake, steering and gas manipulation for smooth, coordinated vehicle operation	a. Choose best escape route
b. (Failure to) practice proper SOP* for situation	

ANTECEDENT	PRECIPITATING
2. Discriminations a. (Failure to) detect potentially hazardous situations (1) Environmental cues (a) Road, light, weather conditions (b) Traffic density (2) Vehicular cues (a) Proneness to skids (b) Rapidity of acceleration, deceleration (3) Human cues (a) Possible results of an action (based on knowledge of situation and related experience)	2. Discriminations a. Recognition of hazardous situation
3. Motor Responses a. (Failure to) practice motor responses related to smooth coordinated operation of vehicle and implementation of proper SOP* (scanning techniques, hand signals, etc.)	3. Motor Responses a. (Failure to) respond properly or adequately (1) Turn wrong way in skid (2) Over control (3) Apply brakes hard in skid or on slick pavement (4) "Freeze" on controls (5) Accelerate too rapidly (6) "Tangential" (abrupt, jerky) steering
4. Motivation a. Overestimate driving ability b. Underestimate dangers of situation c. Assume other traffic will follow SOP* and exhibit "good" ability d. Tendency to not project consequence of actions into future	4. Motivation a. Panic
5. Habits	5. Habits a. Slam on brakes when in danger
6. Physiological a. Sensory-motor coordination	

**Safe Operating Procedures*

ANALYSIS OF MISPERCEPTION Accidents attributed to visual causes accounted for 8.2% of the total accidents in the 1952-1953 period. These accidents were of three major types; those due to misjudgment of rate of closure, those resulting from the driver's failure to compensate for reduced visibility (fog, sun glare, etc.) and those resulting from the driver's failing to understand what he saw. These will be considered separately below.

1. *Distance and Rate of Closure.*

These accidents were precipitated by driver failure in estimating the distance and/or speed of the vehicle ahead. Typical driver statements include:

a. "I wanted to pass the truck ahead of me and, as I got close, I started to cut around him. I didn't realize I was so close and just nicked the left hand corner of his trailer."

b. "I wanted to park and let my motor cool so I pulled in behind this truck already parked on the berm. I must have misjudged the distance because before I knew it I had slid right into his rear end."

Drivers quickly become adapted to higher speeds and tend to forget the rate at which they're traveling. When the occasion to pass another vehicle arises the driver quite likely starts his turnout at a distance comparable to that utilized at lower speeds. He feels he has enough room to clear the preceding vehicle but his judgment of relative speeds has been distorted. As the preceding vehicle is approached it serves as a cue for the judgment of speed of closure; the closer this vehicle is, the more easily and accurately is this judgment made. In the accidents in this category, however, the judgment was not accurately made until too late to avoid a collision.

Approaching a toll booth, entering a gas station, or parking along the berm all involve similar processes. Drivers misjudge their stopping distance and the speed at which they are traveling as a function of two factors: (1) "negative adaptation" to speed and (2) the absence of "cues-in-close-proximity" by which to judge their speed.

The nature of the process(es) termed "negative adaptation" to speed is not clearly defined by current knowledge. Fruitful research could be performed in this area since the effects of erroneous judgment of distance, speed and rates of closure are not necessarily limited to this class of accidents alone. For example, in those accidents grouped in "Deficiencies in Routine Driving Skills", this phenomenon could be involved in those accidents in which a passing driver goes into the medial strip. It is possible these drivers misjudged the distance of the preceding vehicle and were forced to swing out sharply to the left, thus entering the medial. This phenomenon could also be involved in that group of accidents in "Illegal and Unsafe Actions" in which drivers pull out in front of passing vehicles after having misjudged the speed or rate of closure of the vehicle passing them.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors related to higher speeds:	
a. Ideal weather, road conditions	
b. Roadway engineered for high speed travel	

ANTECEDENT	PRECIPITATING
2. Factors related to the absence of cues: (1) Wide pavement (2) Wide berm (3) Absence of fences, homes, etc. close to roadway	
B. Vehicular Factors	
1. Factors related to high speeds: a. Vehicle design (1) High horsepower (2) Vehicle comfort (3) Ease of handling	
2. Factors related to absence of cues: a. Smooth ride b. Low engine noise (body insulation, etc.)	
C. Human Factors	
1. Decisions a. (Failure to) travel at accustomed speeds	1. Decisions a. Pass vehicle ahead b. Stop for exit, gas station, etc. c. Best possible escape route
2. Discriminations a. Speedometer indicates high speed	2. Discriminations a. Collision inevitable
3. Motor responses a. Routine brake, gas, steering manipulation	3. Motor responses a. Brake, gas, steering coordination involved in escape route
4. Motivation a. Test limits of environment b. Overestimate ability c. Underestimate hazards	4. Motivation a. Avoid collision
5. Physiological a. Negative adaptation to speed	

2. *Reduced Visibility*

As would be expected from the title, accidents in this category were precipitated when vision became obscured. Typical driver statements for this category include:

a. "A car which was passing me threw slush on my windshield and I couldn't see a thing. Before I knew what had happened I had run off the road into the guard rail".

b. "The fog was very heavy and I slowed down. I must have run off the road and then I hit the bank".

c. "I was blinded by headlights coming the other way while trying to pass the car ahead of me. I hit the car I was passing".

Human factors contributing to this class of accidents are similar to those involved in "Ambiguity of Cues". In both cases the violation of safe procedures contributed to setting up a potentially dangerous situation. Maintaining proper vehicle spacing would have helped decrease the likelihood of an accident even after vision became obscured. This is not to say, of course, that all accidents would have been eliminated by these procedures.

In both cases lack of knowledge and projecting the consequences of actions into the future are involved. Probably most drivers know it takes time to become adjusted to changes in illumination (as when entering a dark tunnel after travel on a sunlit highway.) Drivers may not know, however, the distance they travel at different speeds while this adaptation is taking place.

A similar observation, in a different area, involves the knowledge of the effect of using windshield wipers on a slush-splattered windshield. In some cases vision is less impaired through the splattered windshield than it is after hasty wiper action has smeared the slush into an opaque film.

In summary, the contribution of human factors for this category consists essentially in the violation of safe procedures through poor attitudes or ignorance of proper procedures.

To outline this analysis:

ANTECEDENT

A. Environmental Factors

1. Factors contributing to reduced visibility:
    - a. Wet, slush, dust or mud
    - b. Low setting sun
    - c. Heavy rain, snow, hail, fog
    - d. Opposing headlights
    - e. Other traffic
    - f. Decreased illumination in tunnels

B. Vehicular Factors

1. Factors related to poor visibility:
    - a. Inefficient windshield wipers
    - b. Tendency for windshield to steam up when not ventilated
    - c. Headlights

C. Human Factors

1. Decisions
    - a. Obey SOP

PRECIPITATING

1. Decisions
    - a. Best escape route

ANTECEDENT	PRECIPITATING
2. Discriminations	2. Discriminations
a. Potential hazards (combinations of A, B, and C)	a. Ambiguous or hazy visual display
3. Motor Responses	3. Motor Responses
a. Brake, gas, steering manipulation	a. Brake, steering, gas coordination in following escape route
4. Motivation	4. Motivation
a. Test limits of environment	a. Stop when in danger
b. Overestimate ability	
c. Failure to project consequences of actions into future	
5. Habits	5. Habits
	a. Slam on brakes when in danger
6. Physiological	6. Physiological
	a. Dark adaptation

3. *Ambiguity of Cues*

These accidents were precipitated by drivers becoming confused by what they saw. Typical driver statements include:

a. "I pulled behind a lighted trailer thinking he was on the road traffic lane. When I discovered he was parked, it was too late to miss him".

b. "I became confused by the service station lights and the entrance ramp to the station. I cut to the left off the road because of what I thought was a parked trailer".

Drivers probably contribute to their difficulty in seeing by utilizing poor scanning procedures, e.g., using the tail lights of vehicles ahead as direction cues rather than continual scanning of both road edges and the painted white lines separating lanes.

Violation of other procedures is probably involved in this category also. If, for example, drivers maintained safe distances between their own and preceding vehicles, they would enjoy a proportionate increase in the time available to interpret their environment correctly. Similarly, lower speeds in those environmental settings conducive to ambiguity (night travel in rainy weather when opposing traffic is heavy, for example) would result in an increased period of time in which to "see" the situation correctly. Violation of these procedures is probably related to driver failure in predicting future potential hazards of present behavior, i.e., the same tendency to expect continuance of the status quo mentioned in previous categories. Lack of knowledge concerning potential dangers is probably of importance here also, since we usually feel secure in our faith that what we can "see" we can understand.

In summary, the human factor for this class of accidents consists primarily of the violation of safe procedures. These violations range from faulty scanning habits to traveling at speeds too fast for conditions at the moment, and are most probably related to poor attitudes or a lack of knowledge on the part of the driver.

To outline this analysis:

ANTECEDENT	PRECIPITATING
A. Environmental Factors	
1. Factors related to poor visibility:	1. A combination of factors listed at left
a. Inclement weather (rain, fog, etc.)	
b. Night	
c. Wet or glazed road surface	
d. Abrupt changes in illumination	
(1) Tunnels as compared to main roadway	
(2) Lighted areas as compared to unlighted	
(3) Opposing headlights	
B. Vehicular Factors	
1. Factors related to poor visibility:	
a. Vehicle condition	
(1) Windshield wipers	
(2) Headlights	
C. Human Factors	
1. Decisions	1. Decisions
a. Travel at safe speed for condition	a. Best escape route
2. Discriminations	2. Discriminations
a. Potentially hazardous combination of factors listed previously (glare, etc.)	a. Ambiguous visual display
3. Motor responses	3. Motor responses
a. Combination of brake, gas, steering manipulations necessary in routine driving	a. Responses involved in following escape route (brake, steering, gas coordination)
4. Motivation	4. Motivation
a. Test limits of environment	a. Stop when in danger
b. Overestimate ability	
c. (Failure to) project consequences of actions now into future.	
5. Habits	5. Habits
	a. Slam on brakes when in danger
6. Physiological	6. Physiological
a. Dark adaptation	a. Failure to adapt quickly enough to abrupt changes in intensity of illumination

ANALYSIS OF FAILURE TO AVOID OBJECTS IN ROAD

Accidents involving objects in the road (rocks, deer, dogs, etc.) accounted for 3.6% of all accidents on the Turnpike in the period studied. Driver's statements typical for this category are:

a. "I was driving along when all of a sudden a deer darted in front of me".

b. "All of a sudden a rock fell on the road in front of me".

c. "All at once I came on this rock lying right in the middle of the road".

It is doubtful if there is much a driver can do when confronted by an object suddenly appearing in his road path if he has not anticipated this possibility beforehand and adjusted his driving behavior accordingly. Perhaps quick evasive action could decrease the number of accidents in this category.

Probably much more pertinent for this class of accidents is the tendency on the part of drivers to override their headlights. This is easily accomplished in modern cars on a super highway such as the Turnpike. Ignoring the warning in the form of signs announcing the likelihood of rocks or animals in the area, this tendency would be completely uninhibited. When opposing traffic requires headlights to be on low beam the situation is increasingly hazardous.

Drivers are also handicapped at night in that the side of the road is not illuminated and scanning of this sector is not facilitated. Forewarning of the approach of an animal is not possible in this situation to any great extent.

Probably the most concise summary of the human factor for this class of accidents consists of the statement that accidents here are the result of a failure on the part of the driver to see an object in time to avoid hitting it. Sometime this failure is the result of a driver not allowing for this contingency (by such actions as overriding headlights); other times the event is clearly unavoidable, regardless of the vigilance of the driver. The degree of importance to attach to each is not ascertainable at this time.

To outline this analysis:

ANTECEDENT

A. *Environmental Factors*

1. Wooded areas where deer and other animals would be expected
2. Farm areas where dogs, would be expected
3. Cliff-like terrain where rocks, dirt slides, etc., would be expected
4. Symbolic
   (a) "Fallen Rock Zone"
   (b) "Caution—Slides"
   (c) "Animals" (Deer)
5. Breaks in fences, height of fences.

B. *Vehicular Factors*

1. Speedometer — speed indicated is incompatible with distance illuminated by headlights (night) overriding headlights at these times

PRECIPITATING

1. Sudden appearance of object on road

(Continued on Page 66)

ANTECEDENT	PRECIPITATING
2. Headlights on "low beam"	
3. Vehicle weight — less damage to truck	
C. Human Factors	
1. Discriminations	1. Discriminations
(a) Speedometer reading (See B1)	(a) Object in road
(b) Red light indicating "high beams" on or off (night time)	(b) Stopping distance inadequate
(c) Symbolic environment	
(d) Natural environment whose nature indicates possibility of rocks, animals, etc.	
2. Decisions	2. Decisions
(a) (Failure to) adjust driving speed and scanning techniques in light of knowledge that an object may "suddenly" appear on road (Season of year, terrain of area, etc.)	(a) Best possible (weight of vehicle) escape route (if other vehicles are present in passing lane or along berm, a collision course with the object may be the "best" course for those conditions
(b) Use high beams whenever traffic conditions permit	(b) Extreme use of brakes
3. Motor Responses	3. Motor Responses
(a) Adjust speed by pressure on accelerator	(a) Extreme pressure on brake pedal
(b) Manipulate headlight beam switch	(b) Manipulate steering to travel "best" possible course
4. Motivation	4. Motivation
(a) Test limits of system (override headlights, etc.)	(a) Avoid (immediate) direct danger even though alternate may be potentially more dangerous e.g. — avoid a deer by going into and across medial strip even when opposing traffic is present
(b) Overestimation of ability to cope with emergencies	
5. Habits	5. Habits
	(a) Slam on brakes when in danger
6. Physiological	
(a) Reaction time	

ANALYSIS OF INTOXICATION This category consists of those accidents precipitated by drunken driving. These represent 1.2% of the total.

The primary factor in this area, of course, is the effect of alcohol on the physiological processes of drivers. Lengthened reaction times, blurred vision, decreased perceptual-motor coordination, and so on, are well known companions of intoxication. Equally well known is the fallacious assumption by many drivers that their ability is not critically impaired by alcoholic excesses. These individuals feel they are always capable "of making it home all right." The facts are that 37 of them did not "make it" during 1952-1953.

FURTHER ANALYSES OF THE HUMAN FACTOR IN ACCIDENTS Since most persons' familiarity with highway accidents is limited to newspaper accounts of the number killed or injured annually, an attitude of anonymity is built up toward accident victims. Persons tend to lose sight of the fact that accidents are caused by, and involve, other human beings. In the previous section we have reviewed the ways in which persons involve themselves in Turnpike accidents. The present section will be directed toward describing the types of people who experienced accidents on the Pennsylvania Turnpike.

In carrying out the following analysis, business machine cards were punched for each driver who was judged to be primarily responsible for causing an accident. Each card contained such information as: the police accident report number, the causal factor (coded according to the classification of causal factors previously listed in this section), the age and sex of the driver, the state of registration of the vehicle, etc. By comparing tallies of the frequencies of each of these items with the frequencies that would normally be expected, one can determine whether important relationships exist. For example, if ten per cent of the Turnpike patrons are women it would normally be expected that they would account for only ten per cent of the accidents in any category of the classification. If they should account for substantially more than their expected share of accidents in any given category it could be surmised that they are more "prone" to have this type of accident.

Unfortunately, it is extremely difficult and costly to get representative "base-line" (vehicle miles driven) data for many of these categories. To get a representative sample indicating the proportion of women drivers, for example, it would be necessary to consider that women probably drive the Turnpike more frequently:

(a) During the day than at night
(b) During the summer than the winter
(c) On weekends than week days, and
(d) On some parts of the Turnpike than on others

To get base-line it would be necessary, therefore, to take periodic counts throughout the year and at various points on the highway.

A second procedure which can be profitably employed is to compare the frequency of accident involvement under certain conditions with the frequency of involvement under all other conditions. Following this procedure with the example cited above, it might be discovered that women drivers caused ten per cent of all accidents but only five per cent of those accidents classified under Illegal and Unsafe Actions. In this manner, relationships can be found which will direct future investigations away from unproductive research into channels that may be expected to pay dividends in terms of accident reduction.

For economy of time, and because of the tremendous difference in cost, the second method of analysis was adopted for the present behavioral study. It is interesting to note, in the data presented below, how this procedure brings out significant relationships between driver behaviors and other accident characteristics.

1. *Passenger car and truck drivers*

During 1952 and 1953 passenger car drivers were responsible for causing 75.3% of all the accidents studied. But they were responsible for 91% of the accidents classified under

Failure to Cope With Road Conditions and 91% of the accidents classified under Failure to Avoid Objects in Road. They were also responsible for 87% of the accidents listed under Deficiencies in Routine Driving Skills. On the other hand, truck drivers, who were responsible for 24.7% of all accidents classified, accounted for 35% of the accidents classified under Illegal and Unsafe Actions and 46% of accidents attributed primarily to Vehicular Failure. See Table II-2.

TABLE II-2

Per Cent of Passenger Car and Truck Drivers Responsible for Accidents Classified According to Precipitating Factor**

Factor	Number of Accidents	Percentages: Passenger Car Drivers	Percentages: Truck Drivers	Total
Failure to Cope With Road Conditions	686	91	9	100
Illegal and Unsafe Actions	671	65	35	100
Vehicle Failure	430	54	46	100
Asleep	412	75	25	100
Deficiencies in Routine Driving Skills	365	87	13	100
Misperception	257	73	27	100
Inattentiveness	124	74	26	100
Failure to Avoid Objects in Road	114	91	9	100
Miscellaneous*	59	81	19	100

**Includes Intoxication and Miscellaneous*

***Contingency tables containing raw data will be found in the appendices for each table presented in Chapters II and III.*

Because differences listed above were significant, the further analyses presented below will consider separately the driver behaviors of these groups.

2. *How Vehicle Was Involved*

Rear-end collisions are the largest single type of accident. Approximately 30% of all accidents caused by passenger car drivers and approximately 42% of all accidents caused by truck drivers resulted in rear-end collisions. In addition, 37.5% of all passenger cars and 47.6% of all trucks involved in accidents were involved in accidents of this type.

The question, then, is just what did the drivers do, or fail to do, that resulted in such a high proportion of rear-end collisions. It should be pointed out that any accident-precipitating behavior could, depending on the circumstances, result in a rear-end collision. Not all behaviors, however, had equal rate in rear-end collision accidents. Certain behaviors on the part of drivers resulted in a higher number of rear-end accidents than would normally be expected on the basis of comparison with other driver behaviors. These are presented in Table II-3 together with other precipitating factors which were responsible for more than their "share" of other types of vehicle involvement.

Rear-end type collisions, for example, occur proportionately more often because of Asleep, Misperception and Illegal and Unsafe Actions. Conditions conducive to a driver falling asleep are discussed in the behavioral section of this chapter.

Illegal and Unsafe Actions is seen to be one of the major behavioral categories. A number of these actions tie in with the significantly high number of passenger cars involved in rear-end collisions, e.g., cutting in too quickly after passing, pulling out in front of a passing vehicle, slowing down suddenly, stopping on the highway, failing to set brakes while parked, and following too closely, are some of the actions which contributed to the high frequency of rear-end collisions.

Accidents involving vehicles which are Stopped, Stopping, or Parked are disproportionately high for the Illegal and Unsafe Action behavior category for both passenger cars and trucks. Accidents involving vehicles Stopped, Stopping, and Parked were the result of such actions as stopping on the highway, entering the berm at high speed and losing control, failure to set brakes properly while parking, and failure to check to rear before backing up.

Sideswiping accidents were found to be the result of such actions as: pulling out in front of passing vehicle, passing vehicle on the right side, attempting to pass in "no-passing" zones, cutting in too quickly after passing, drifting over the center line, and making U-turns.

The behavioral category Failure to Cope with Road Conditions is related to Running Off Roadway accidents for passenger cars. In addition, however, Running Off Roadway accidents are also seen to be related to Deficiencies in Routine Driving Skills. The act of slamming on brakes on icy highway, and running off the road on to the berm and losing control play a part in these accidents.

TABLE II-3

Significant Relationships Between Various Driver Behaviors And How Vehicle Was Involved

How Vehicle Was Involved	Passenger Cars	Trucks
Rear-end Collisions	Asleep; Illegal and Unsafe Actions; Misperception	Asleep; Misperception
Stopped, Stopping and Parked	Illegal and Unsafe Actions	Illegal and Unsafe Actions
Medial Strip	Failure to Cope With Road Conditions	
Collisions With Objects Other Than Vehicles	Failure to Avoid Objects in Road	Vehicle Failures
Overturning	Vehicle Failures; Deficiencies in Routine Driving Skills	Vehicle Failures
Fire Only	Vehicle Failures	Vehicle Failures
Running Off Roadway	Failure to Cope With Road Conditions; Deficiencies in Routine Driving Skills	Vehicle Failures
Sideswiping	Illegal and Unsafe Actions	Illegal and Unsafe Actions

Truck Running Off Roadway accidents, on the other hand, were found to be related to Vehicle Failures. One possible reason for this is that trucks travel the slow lane of traffic the majority of the time.

Both passenger car and truck Overturning, and Fire Only accidents are highly related to particular Vehicle Failures. In addition, however, passenger car Overturning accidents are also disproportionately high in the Deficiencies in Routine Driving Skills category.

In summary, it can be seen that the various types of accidents are related to the various behavioral actions on the part of drivers. Probably the most noteworthy finding in this area is that concerned with the high number of Rear-end collisions. These accidents, representing a large proportion of the total accidents, are significantly related to the passenger car driver falling asleep, misjudging the rate of closure, and committing illegal and unsafe actions.

3. *Weekend Drivers*

Passenger car involvement in accidents are most frequent on Saturday and Sunday. These two days account for approximately 42% of the total passenger car involvement. Truck involvement, on the other hand, reveals a much more constant pattern than does passenger car involvement.

A look at the significant relationships found between day-of-week accident involvement and driver behavior reveals that a very real difference may exist between weekend and week-day drivers, depending on the difficulty of the driving conditions.

As is indicated in Table II-4, week-end drivers are involved in a disproportionately high number of accidents as a result of the driver's inability to handle adverse roadway conditions.

A possible explanation for the significantly high number of passenger car "Vehicle Failure" on Wednesday and truck "Vehicle Failure" on Friday is not apparent.

The relatively high number of passenger car intoxication accidents on Friday is probably due to larger numbers of drinking drivers on the road on that day.

In summary, week-end drivers are apparently less capable of coping with adverse roadway conditions. This fact is further magnified when it is realized that week-end drivers have some degree of choice over the weather and roadway conditions in which they choose to drive. Most pleasure driving is done during favorable weather conditions.

4. *Women Drivers*

An analysis, similar to those described above, was carried out for male and female passenger car drivers. It was found that the women driver falls asleep at the wheel significantly less frequently than would be expected. Although women drivers account for 17% of the passen-

TABLE II-4

Significant Relationships Between Various Driver Behaviors And Day of Week Accidents

Day of Week	Passenger Cars	Trucks
Sunday	Failure to Cope with Road Conditions	Failure to Cope with Road Conditions
Wednesday	Vehicle Failures	
Friday	Intoxication	Vehicle Failures
Saturday	Failure to Cope with Road Conditions	

ger car accidents, they account for less than 8% of Asleep accidents. On the other hand, they cause 31% of the accidents attributed to Deficiencies in Routine Driving Skills.

5. *Youthful Drivers*

As was mentioned above, it was not considered feasible to attempt to determine the proportion of drivers in various age groups who comprise the Turnpike population. But by comparing the frequencies with which drivers in the various age groups experience different kinds of accidents it is possible to discover important relationships, if they exist.

With respect to passenger car drivers in the 16-25 year age group (who account for 38.5% of passenger car accidents), it was found that they cause 58% of the Falling Asleep accidents. Drivers 46 years of age and older are involved in significantly few accidents of this type.

On the other hand, drivers 56 years and older are involved in more accidents attributed to Deficiencies in Routine Driving Skills than would be expected by chance.

Among truck drivers, no differences were found among the various age groups with respect to type of accident.

6. *Out-of-State drivers*

No differences were noted among local and out-of-state truck drivers with respect to .their frequency of involvement in accidents of various types. Among passenger car operators, a slight but significant tendency was noted for Pennsylvania drivers to be involved in fewer accidents attributable to Failure to Cope With Road Conditions. One explanation might be that the local driver has the option to stay at home during inclement weather.

During the period October 1-15, 1952, the Pennsylvania Turnpike commission made a tally of the state of registration of all vehicles using the Turnpike facilities. Although the resulting figures are for only a limited portion of the year they may serve as a first approximation of the proportion of state representation throughout the year.

It was found that 63.6% of the vehicles using the Turnpike during this period were of Pennsylvania registration. Yet only 37.6% of the drivers causing accidents during 1952-1953 were driving vehicles registered in Pennsylvania.

On the strength of this finding, two further analyses were carried out to discover whether drivers from various states actually differed with respect to the types of accidents in which they were involved.

The first analysis consisted of correlating the number of accidents experienced by drivers from various states during 1952-1953 with the frequency with which these states were represented on the highway during the two-week period selected for "Base-line". These proportions are presented in Table II-5. A rank-order correlation of .992 was obtained, indicating a nearly perfect relationship between exposure and accident involvement. It would seem that no state can justifiably lay claim to having the "best" drivers.

It is interesting to note in consideration of in-state and out-of-state drivers that despite the various driving experiences common to the different states, accident involvement on the Turnpike was directly proportional to exposure. As could be expected the highest percentage of accidents were accounted for by the high population states or those states adjacent to Pennsylvania.

The Turnpike is populated by drivers from all of the 48 states; drivers who are exposed to a wide variety of driving environments, who in some instances operate under differing traffic laws, who generally travel on roads, in some cases similar, but most often unrelated to Turnpike travel. The surprising fact, relative to drivers from the various states, is that this ostensibly heterogeneous group displays a high degree of homogeneity of behavior in so far as accident involvement on the Turnpike is concerned.

TABLE II-5

Relationships Between Per Cent of Vehicles from the Various States (N=474, 376) and Per Cent of Accidents Sustained (N=3086)*

State	% of Veh.	% of Acc.	State	% of Veh.	% of Acc.
Pennsylvania	63.60	37.60	Arkansas	.03	.30
Ohio	11.00	16.20	Georgia	.20	.30
New York	3.70	7.40	Kansas	.10	.20
Michigan	3.20	7.30	South Carolina	.10	.20
New Jersey	3.80	6.40	Tennessee	.10	.20
Illinois	2.20	3.90	Nebraska	.10	.20
Indiana	1.80	3.00	Colorado	.10	.20
Maryland	1.80	2.90	Oklahoma	.10	.20
Virginia	1.10	1.80	Washington	.10	.20
West Virginia	.50	1.20	North Dakota	.02	.10
California	.60	1.10	Maine	.10	.10
Florida	.50	.90	New Mexico	.05	.10
Massachusetts	.60	.80	Montana	.03	.10
Connecticut	.50	.80	Nevada	.02	.10
North Carolina	.30	.80	Oregon	.04	.10
Delaware	.50	.70	Vermont	.04	.10
District of Columbia	.40	.70	Arizona	.05	.00
Missouri	.40	.60	Idaho	.03	.00
Texas	.30	.60	Louisiana	.10	.00
Minnesota	.30	.60	Mississippi	.04	.00
Iowa	.20	.60	South Dakota	.02	.00
Alabama	.20	.50	Utah	.02	.00
Wisconsin	.40	.50	Wyoming	.03	.00
Rhode Island	.20	.40	New Hampshire	.05	.00
			Total	99.67	100.00

**rho=992.*

The second analysis consisted of comparing the frequencies of accidents in each of the behavior categories for the drivers from the nine states accounting for most accidents during the two year period studied. These data appear in Table II-6. No differences were noted. The out-of-state driver is no better, and no worse, than his Pennsylvania counterpart.

TABLE II-6

Comparison of Types of Accidents Experienced by Drivers From Nine States (Passenger Cars and Trucks)

	Penna.	N. Y.	N. J.	Ohio	Mich.	Ill.	Ind	Md.	Va.	Total
Vehicle Failures	163	30	28	52	42	19	9	15	8	366
Failure to Avoid Objects in Road	51	8	5	19	6	6	2	6	0	103
Failure to Cope With Road Conditions	223	61	45	123	45	20	17	19	21	574
Inattentiveness	200	31	35	99	41	19	15	15	10	465
Deficiencies in Routine Driving Skills	132	30	23	62	24	13	11	10	3	308
Illegal and Unsafe Actions	257	46	35	100	46	31	30	17	8	570
Misperception	103	19	26	33	17	10	9	5	5	227
Miscellaneous*	30	3	1	11	3	2	1	1	0	52
Total	1159	228	198	499	224	120	94	88	55	2665

*Includes Intoxication and Miscellaneous.

7. *Occupational Analysis*

In an earlier section, the anonymity of accident statistics was mentioned. Nowhere, perhaps, is this more clearly exemplified than in a survey of the occupations of the drivers causing accidents. In the face of widespread publicity it is difficult to realize that truck drivers are not the only persons who experience mishaps on the Turnpike.

A tally was made of occupations represented by drivers who caused accidents during 1953. The 139 various occupations are presented on page 74.

For purposes of further analysis, the occupations are classified under more general headings, e.g., "Transportation" covers truck drivers, cab drivers, bus drivers, professional auto drivers, etc.

The state police accident reports generally listed as "Vehicle 1" the vehicle which did the striking. It was believed that a rough indication of driver competence within the occupational groups might be expressed as the ratio between the number of "strikers" and the number of "struck". This information is presented in Table II-7, page 75.

OCCUPATIONS OF DRIVERS CAUSING ACCIDENTS
1953

accountant
alderman
architect
army employee
artist
assembler
assemblyman

bank teller
barber
bartender
bookkeeper
brakeman
bricklayer
brush maker
builder
bus driver
business agent
business man
buyer

cab driver
cabinet worker
car dealer
caretaker
carpenter
chauffeur
chemist
clerk
collection manager
construction worker
cook
crane operator

dentist
designer
dietician
doctor
dog trainer
domestic
doorman
driver: auto sales
dry cleaner

electrician
engineer
entertainer

farmer
federal employee
foreman
foundry worker
freight agent
fruit grower
fruit peddler
furnace worker

gas station attendant
general manager
grocer
G.S.A. employee

hair dresser
horse trainer
hospital attendant
hostess
housekeeper
housewife

inspector
insurance adjustor
insurance agent
investments adjustor

janitor
journalist

laborer
landscaper
laundry-worker
lawyer
librarian
lineman
linoleum dealer

machinist
mailman
maintenance man
mechanic
medical technician
merchant
meter reader
mill worker
miner
minister
motor vehicle inspector
musician

nurse

office manager
office worker
paper maker
patent attorney
photographer
pipefitter
plumber
policeman
postal clerk
presser
priest
principal
public health educator

rabbi
radar technician
research worker
restaurant proprietor
retired

salesman
sales manager
secretary
serviceman
service station owner
service woman
shipyard rigger
shoemaker
showman
soda jerk
steamfitter
steel worker
store manager
store operator
store owner
student
supervisor
surveyor

teacher
telegrapher
telephone supervisor
tinsmith
toll collector
tool designer
truck driver
typewriter repairman

unemployed
union organizer
union representative
U. S. consul general

waitress
warehouseman
welder

TABLE II-7

Ratio of Striking Vehicles to Vehicles Struck for Various Occupational Groups of Drivers (1953 Data)

Occupational Group	No. of Times Hit Others	No. of Times Were Hit	Ratio
Transportation	303	483	0.63
Managerial	53	43	1.23
Religion	9	7	1.29
Farming	12	9	1.33
Unskilled Labor	172	106	1.62
Professional Services	19	11	1.73
Sales	99	50	1.98
Clerical	66	33	2.00
Politics	2	1	2.00
Professions	53	25	2.12
Education	80	36	2.22
Military	159	67	2.37
Skilled and Semi-Skilled Trades	210	88	2.39
Housewives	92	31	2.97
Unemployed	17	5	3.40
Unknown	52	12	4.33
Entertainment	12	2	6.00
Retired	30	5	6.00

A Chi-Square analysis of the material in Table II-7 revealed significant cell contingencies for Transportation, Military, Housewives, Skilled and Semi-Skilled Tradesman, and Retired persons. In other words, transportation employees (mainly truck drivers) are hit by other occupational groups significantly more often than they hit. The other four occupational groups listed above run into other vehicles far more frequently than they themselves are hit.

The accident report numbers describing accidents experienced by each of the above five groups were recorded. Tallies were then made of the factor which was primarily responsible for each group's accidents. This was done to discover the kinds of accidents which are typical for each group, i.e., what kinds of behaviors appear most frequently for the "Hitters" and "Those Hit" which can offer some explanation for this difference. The results of this analysis are presented in Table II-8.

TABLE II-8

Comparison of Various Occupational Groups According to Frequency of Casual Behaviors (1953 Data)

Casual Factor	Occupational Group					Total
	Transp.	Military	Housewives	Retired	Skilled Trades	
Vehicle Failure	102	26	9	3	29	169
Failure to Cope With Road Conditions	34	64	23	6	36	163
Inattentiveness	83	83	12	1	34	213
Deficencies in Routine Driving Skills	23	20	30	4	22	99
Illegal and Unsafe Actions	107	38	11	7	37	200
Misperception	32	16	3	3	20	74
Intoxication	8	5	1	2	5	21
Total	389	252	89	26	183	939

As can be seen from Table II-8, Transportation workers are more likely to be involved in Vehicle Failure accidents and those caused by Illegal and Unsafe Actions. They are infrequently involved in accidents attributable to Failure to Cope with Road Conditions or Deficiencies in Routine Driving Skills.

Military personnel account for a significantly high number of Asleep accidents and accidents due to Failure to Cope with Road Conditions. They are least likely to be involved in Vehicle Failure accidents or in accidents due to Illegal and Unsafe Actions.

Housewives are most frequently involved in accidents caused by Deficiencies in Routine Driving Skills and Failure to Cope with Road Conditions. They are rarely involved as a result of Illegal and Unsafe Actions, Inattentiveness, or Vehicle Failures.

There is a slight indication that Retired persons are least likely to be involved in accidents due to Inattentiveness. Skilled Tradesman account for a slightly higher number of Misperception accidents than would be expected by chance.

It is, perhaps, significant to note that servicemen and truck drivers account for 56% of all Asleep accidents. Each of these groups can be expected to be driving for extended periods of time with insufficient rest; the truck driver in performance of his job and the serviceman attempting to make the most of his leave time. Thus, the accidents caused by falling asleep may be attributed to physical exhaustion rather than the familiar whipping boy—the as yet undemonstrated "highway hypnosis".

8. *Speed*

As was previously mentioned in the present report, speeds at which vehicles were traveling at the time of the accident were obtained from driver statements, statements of disinterested witnesses, and estimates made by the investigating officer. The officers' estimates were based on physical evidence, such as the amount of damage, length of skid marks, etc. As can be seen, there is opportunity for error to creep into the speed figures. It may safely be assumed that there is a slight "shading" of estimated speed toward the lower speed ranges. This underestimation, it it exists, is likely to be fairly consistent, however, so there is ample justification for relating such estimates to driver behaviors. Since the tendency is consistent, relationships will still be disclosed.

An analysis of passenger car and truck driver behaviors by Estimated Initial Speed reveals two general areas of relationships. There seems to be a pattern of "higher speed" and "lower speed" accidents. As may be seen in Table II-9, passenger cars in the high speed ranges are involved in significantly more accidents than would be expected by chance in the categories of Failure to Avoid Objects in Road, Asleep, Attending Other Tasks, and Deficiencies in Routine Driving Skills. Trucks in the higher speed ranges (above 41 mph) also experience significantly more involvements in the categories of Asleep, and Attending Other Tasks as well as accidents due to Misperception.

Passenger car involvements in the lower speed ranges are concerned predominantly with Failure to Cope with Road Conditions, and Illegal and Unsafe Actions. Truck accidents in this speed range are concerned with the same categories, as well as a slight tendency to be disproportionately high for Deficiencies in Routine Driving Skills.

It should be emphasized, at this point, that the driver behaviors found in both the "high speed" and "low speed" categories occur and lead to accidents in *all* speeds. The significant differences mentioned above mean that an erroneous action at high speed is more likely to lead to an accident than the same error at low speed, because of the difference in time available for recovery.

9. Number of Vehicles Involved

One further analysis might be mentioned which casts light upon the effect, in terms of accident severity, of the various casual factors.

For the various categories of casual factors, a tally was made of the number of vehicles involved in each accident. These frequencies were then compared with the numbers of one-vehicle, two-vehicle, and three-or-more-vehicle accidents which occurred during the two year period for which behaviors were studied. A substantial number of significant relationships were discovered.

a. Passenger cars. The following factors generally led to single-vehicle accidents: Vehicle Failure, Failure to Avoid Objects in Road, Failure to Cope with Road Condtions, and Deficiencies in Routine Driving Skills. A disproportionate number of two-vehicle accidents were

TABLE II-9

Significant Relationships Between Estimated Speed and Various Casual Factors

	Vehicle	
Factor	Passenger Cars	Trucks
Vehicle Failure	....	....
Failure to Avoid Objects in Road	51-70+	....
Failure to Cope With Road Conditions	21-40	11-30
Asleep	51-70+	41-60
Attending Other Tasks	51-60	41-50
Deficiencies in Routine Driving Skills	41-50	1-10
Illegal and Unsafe Actions	0-20	0-10
Misperception	....	41-50
Intoxication	71+	....

caused by Asleep or by Misperceptions (misjudgment of rate of closure, primarily). The Illegal and Unsafe Actions category resulted in a disproportionate number of two-vehicle and three-or-more-vehicle accidents.

b. Trucks. Essentially the same relationships found for passenger cars were found for trucks. Vehicle Failures accounted for a disproportionate number of single vehicle accidents. Rarely were other vehicles involved when a truck broke down. On the other hand, Asleep, Misperception, and Illegal and Unsafe Actions resulted in a disproportionate number of two-vehicle accidents.

10. *Near Accident Interviews:*

A "near accident" study was made involving several hundred patrons of the turnpike. These patrons were asked to describe occurrences on the turnpike which they witnessed and which almost led to an accident. The factors precipitating these near accidents were classified and compared with the categories of accident report statements. A rank-order correlation of .85 (corrected for ties in ranks) was obtained between the two.

These interviews yielded information which was relatively free from bias, since the threat of possible legal actions was absent and interviewees remained anonymous. The high degree of correspondence to data taken from accident reports serves as further evidence of the accuracy of State Police accident investigations. Qualitative data gathered during the course of these interviews aided the interpretation of quantitative accident data.

CONCLUSIONS A summary and classification of Turnpike accident reports has revealed that drivers exhibit a wide variety of behaviors in becoming involved in accidents. For most accidents the drivers themselves, by their own statements, are to blame.

Analysis conducted to relate these behaviors to additional driver and accident variables indicate a high degree of logical consistency in the classification of casual factors. It is believed that they may, therefore, be used with confidence as one of the important dimensions of Turnpike accident causation. Their relationship with important weather, light, and road conditions will be discussed in the subsequent chapter.

CHAPTER III

ENVIRONMENTAL FACTORS RELATED TO TURNPIKE ACCIDENTS

INTRODUCTION A combination of one of the world's most modern highways, a clear dry day, moderate traffic density, and a relatively fixed traffic pattern seems the most unlikely setting for an accident situation. However, not only do accidents occur under such circumstances, the greatest single percentage of all accidents occurred under these conditions. Accidents also occurred under environmental conditions which demanded the utmost in driver skill along with those that occurred under "ideal" conditions in which the minimum acceptable skill should have met the requisites of safe driving.

This section of the overall causal analysis, deals with the part played by environmental conditions in the complex accident picture. Environment as it is dealt with in this report refers to the various roadway surface conditions, (dry, wet, snow, etc.) the type of road course (straight, curved, up, down, etc.) and the visibility factors of weather and light conditions.

While basic accident cause can rarely be attributed primarily to these environmental conditions, their weight in modifying driver task and behavior, their effect on the various types of drivers, their effect on the vehicle, and their relationships to the types of accidents must be considered in any complete accident causation analysis.

PROCEDURE The four major environmental conditions (light, weather, roadway conditions and roadway element) are treated in this section of the report from the standpoint of vehicle involvement frequency, vehicle involvement rate, and areas of significant relationship with not only the driver behavior and vehicular accident precipitating factors, but with the other accident factors such as age, sex, type of accident, etc. It should be pointed out that most data in this section of the report refer to vehicle involvement on the main line portion of the highway from 1941-1952, and do not include involvements which occurred in the gas stations themselves, entrance or exit ramps, etc. The tables and discussion relevant to the relationships found between the environmental conditions and specific precipitating factors, however, covers accidents which occurred on all Turnpike property during 1952-1953. While the 1953 data was not yet completed when the overall figures were computed, consistency in data from year to year indicates that the inclusion of 1953 would not have changed the patterns presented in this section.

By frequency of vehicle involvement is meant the actual number of vehicles which were involved in accidents under a given set of conditions. The vehicle involvement frequency is, in other words, the overall accident picture from the standpoint of actual numbers of vehicles involved. Vehicle involvement frequency, therefore, is one measure of the overall severity of the accident situation under a given set of conditions. The frequency figures can be viewed, then, as the gross end result of the interplay of human behavior, environmental conditions, and vehicle mile exposure.

Vehicle involvement rate, on the other hand, takes into consideration both the number of vehicles involved in accidents and the number of vehicle miles driven under each of the environmental conditions. The rate figures thus provide an objective evaluation of the difficulty of the driving task for any given set of conditions. Thus comparison of driving task difficulty for different conditions is possible.

Areas of significant relationships refer to statistically significant relationships found between: (1) environmental conditions and specific precipitation factors (2) combinations of environmental conditions. In both cases "significant relationship" means that the frequency of vehicle involvement was found to be higher or lower than would normally be expected on the basis of chance.

The isolation of significant relationships serves to point out the effect of environmental conditions on the vehicle and driver behavior as well as those factors which contribute disproportionately to the accident frequency and rate under the various driving conditions. In addition, the significant relationships will serve as an invaluable background for future remedial research. The Chi-Square formula, which utilizes the marginal distribution of the data, was used for determining areas of significance.

It is important to point out, in relation to these deviations, that lack of significant relationship does not indicate that the driver behaviors were unimportant. Rather, the lack of a significant relationship is indicative of approximately equal importance of each of the behavioral categories. Even in those cases where significant relationships were found between two factors, the remaining factors cannot be negated. For example; it will be pointed out that while curved down truck accidents were significantly related to truck driver failure to cope with road conditions, other behavioral factors also resulted in accidents on curved down roadway.

The overall scope and general nature of the entire study was covered in Chapter I. The basic aim of this comprehensive study has, unfortunately, necessitated the restriction of hypotheses in many cases. This was particularly important in the following section where prime consideration had to be given to complete coverage of the environmental factors at the expense of tracing each possible hypothesis to its resolution. It will become apparent in reading this section that the integration of the environmental factors with the driver and vehicle precipitating behavior along with the important environmental relationships discovered pose many interesting hypotheses. In many cases resolution of these hypotheses will be apparent to the reader, others however, indicate the need for further, more restricted research. The inferred hypotheses set up through the analysis and integration of the data should, however, serve as guideposts and lead to fruitful further remedial research.

FREQUENCY OF RELATED FACTORS The following accident involvement frequency patterns are presented primarily as a background or preface to the environmental considerations. Each of these factors will be considered under each of the four major environmental conditions, highlighting not only the relative frequency of involvements, but also the areas of significant relationship to the environmental conditions. These graphs cover total vehicle involvement in accidents on the main line of the highway from 1941-1952.

FIG. III-A

PASSENGER CAR ACCIDENT INVOLVEMENT BY HOW VEHICLE WAS INVOLVED

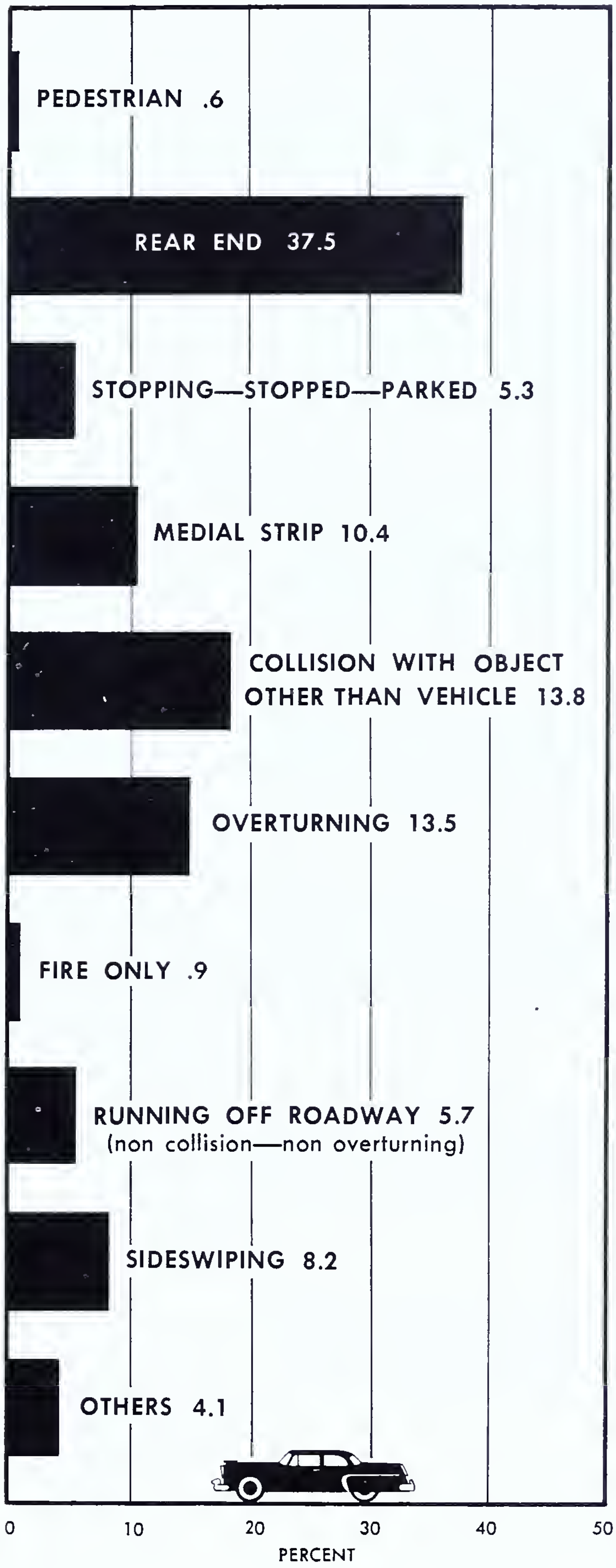


FIG. III-B

TRUCK ACCIDENT INVOLVEMENT BY HOW VEHICLE WAS INVOLVED

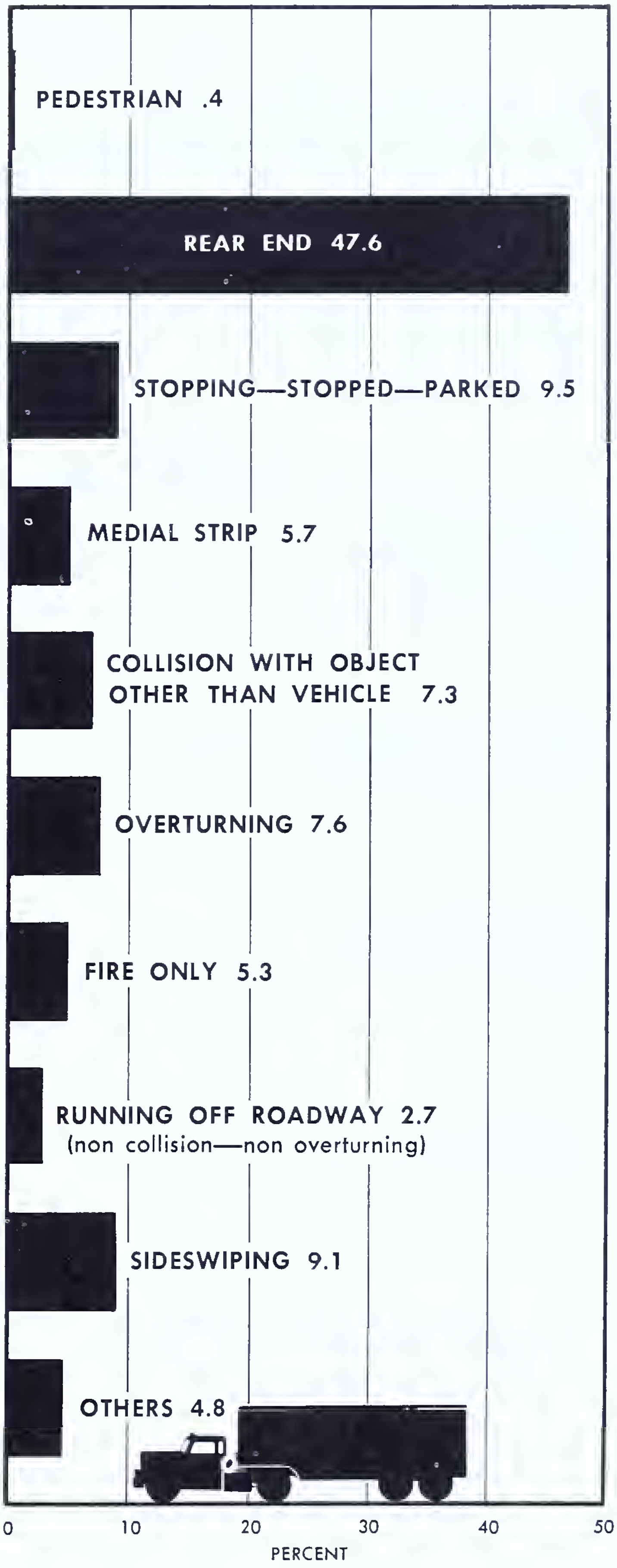


FIG. III-C

PASSENGER CAR INVOLVEMENTS BY DAY OF WEEK

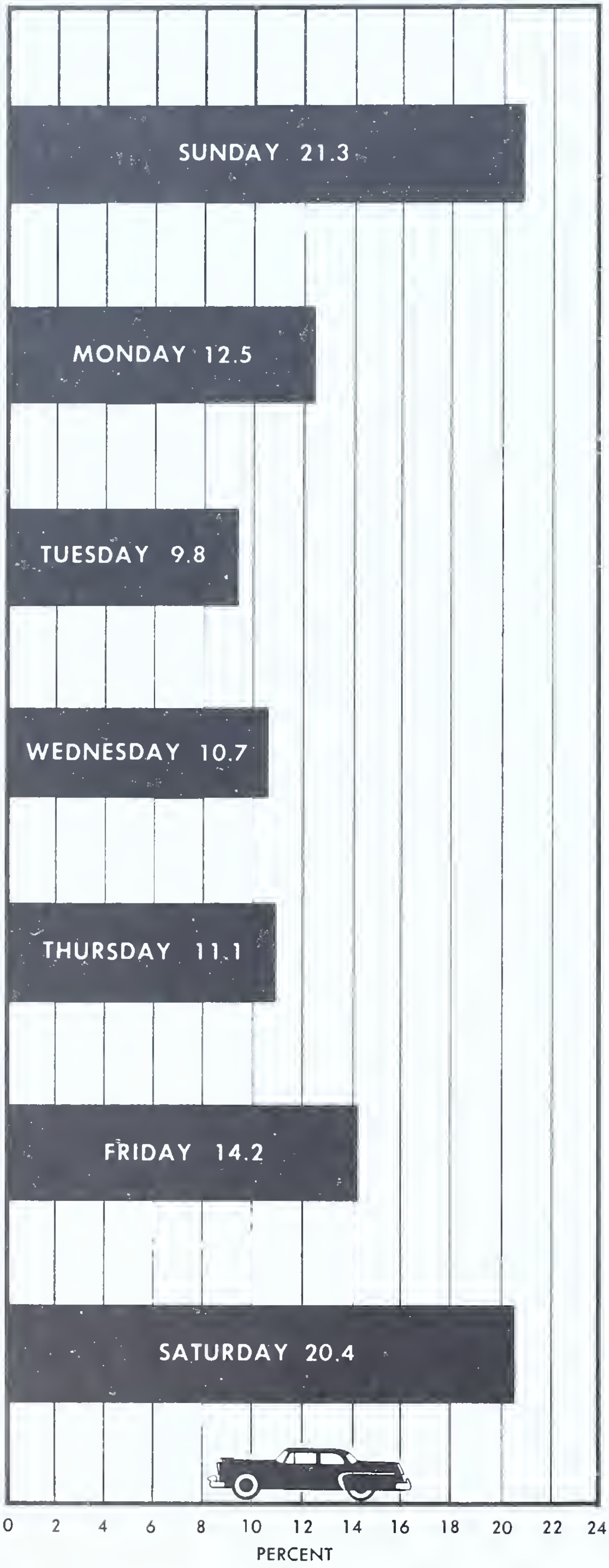


FIG. III-D

TRUCK INVOLVEMENT BY DAY OF WEEK

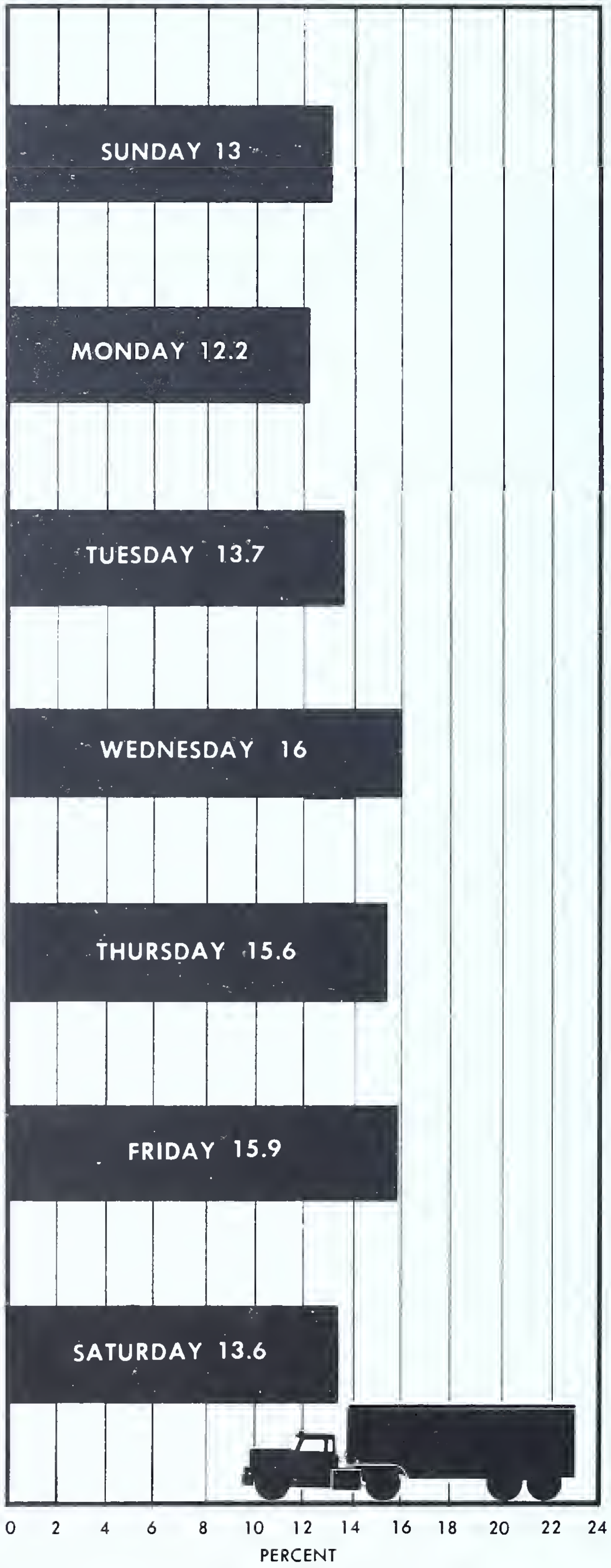


FIG. III-E

PASSENGER CAR INVOLVEMENT BY PLACE

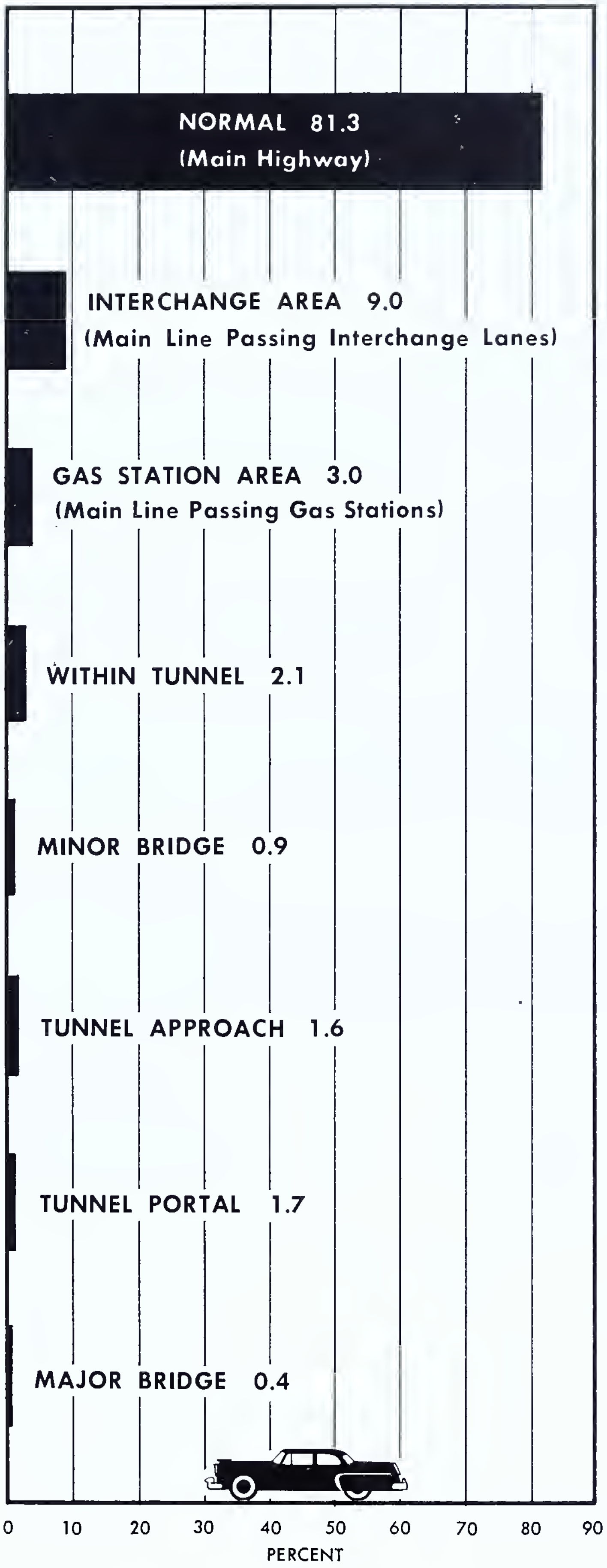


FIG. III-F

TRUCK INVOLVEMENT BY PLACE

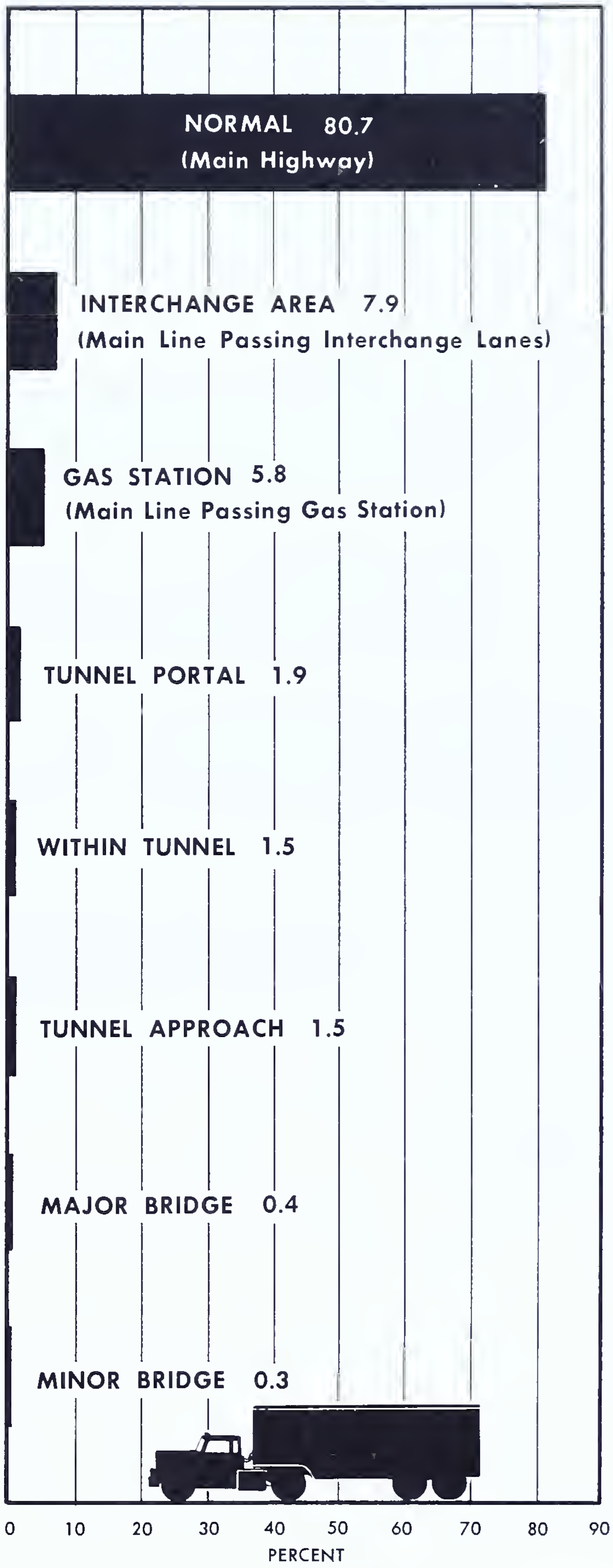


FIG. III-G

PERCENT OF VEHICLES INVOLVED IN ONE, TWO, THREE, VEHICLE ACCIDENTS PASSENGER CARS

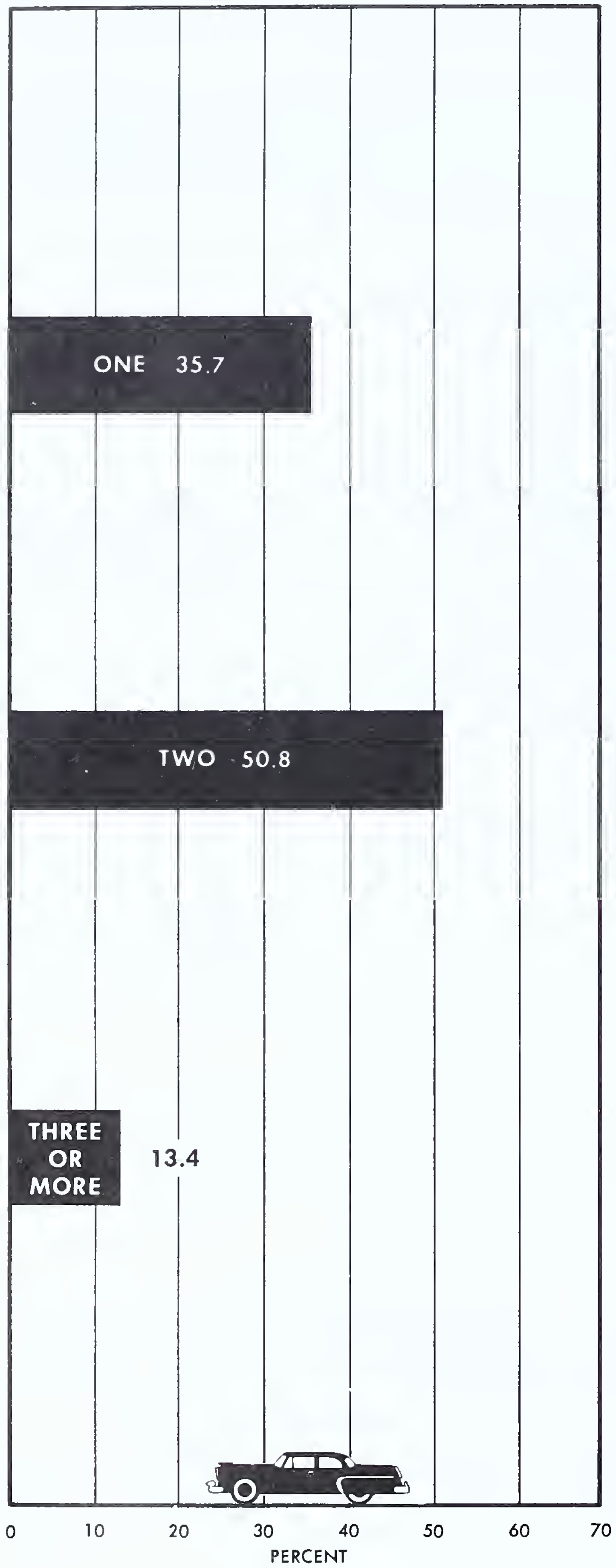


FIG. III-H

PERCENT OF VEHICLES INVOLVED IN ONE, TWO, THREE, VEHICLE ACCIDENTS TRUCKS

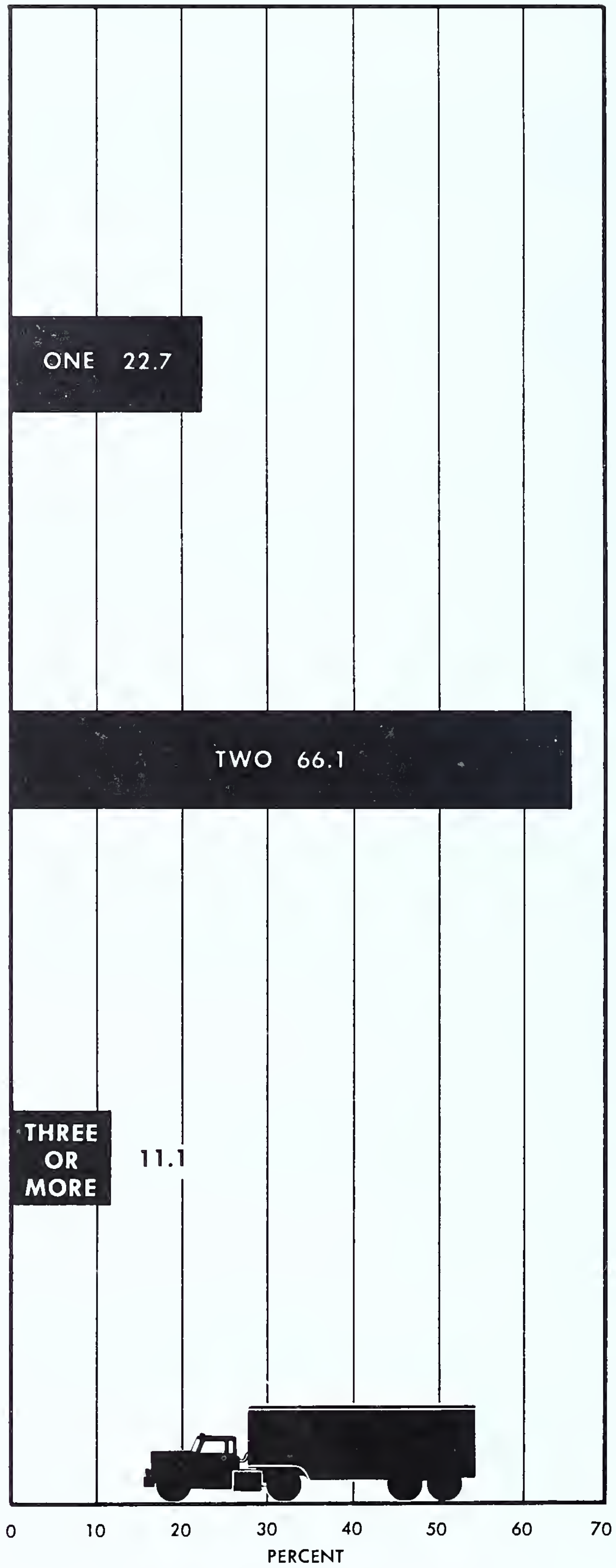


FIG. III-I

PASSENGER CAR INVOLVEMENT BY STATE OF REGISTRATION

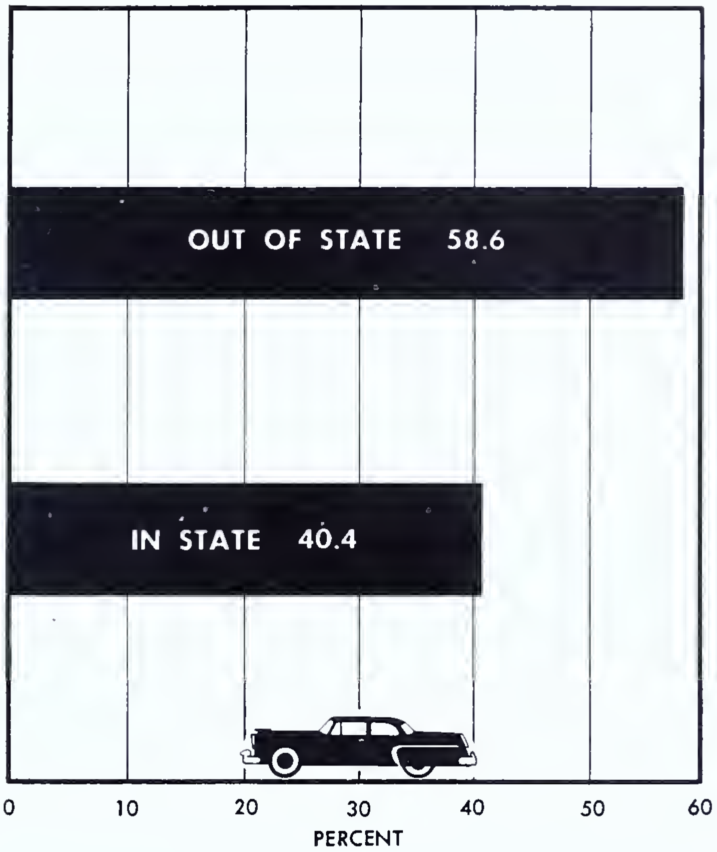


FIG. III-J

TRUCK ACCIDENT INVOLVEMENT BY STATE OF REGISTRATION

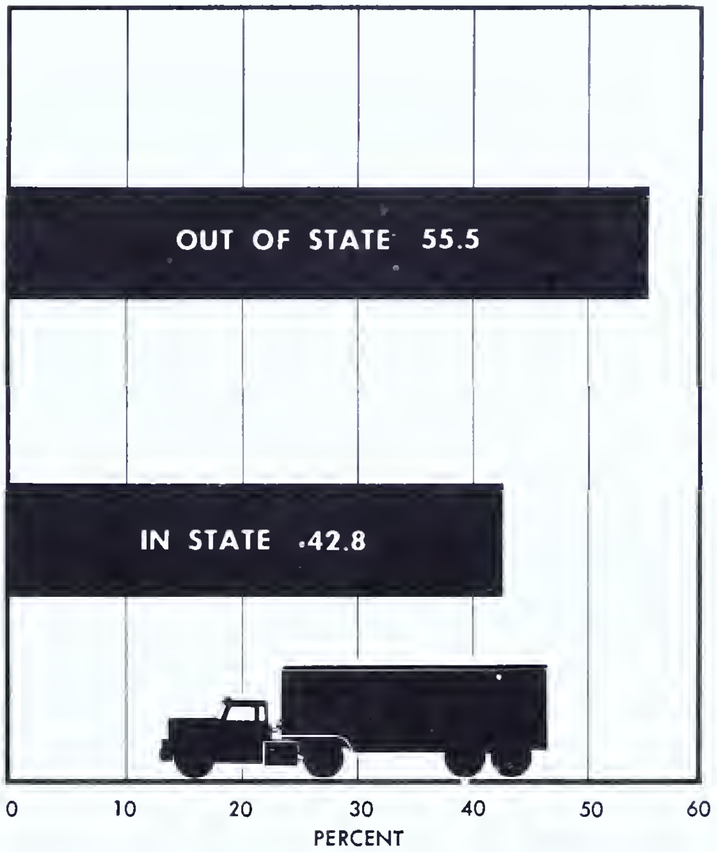


FIG. III-K

PASSENGER CAR ACCIDENT INVOLVEMENT BY SEX OF DRIVER

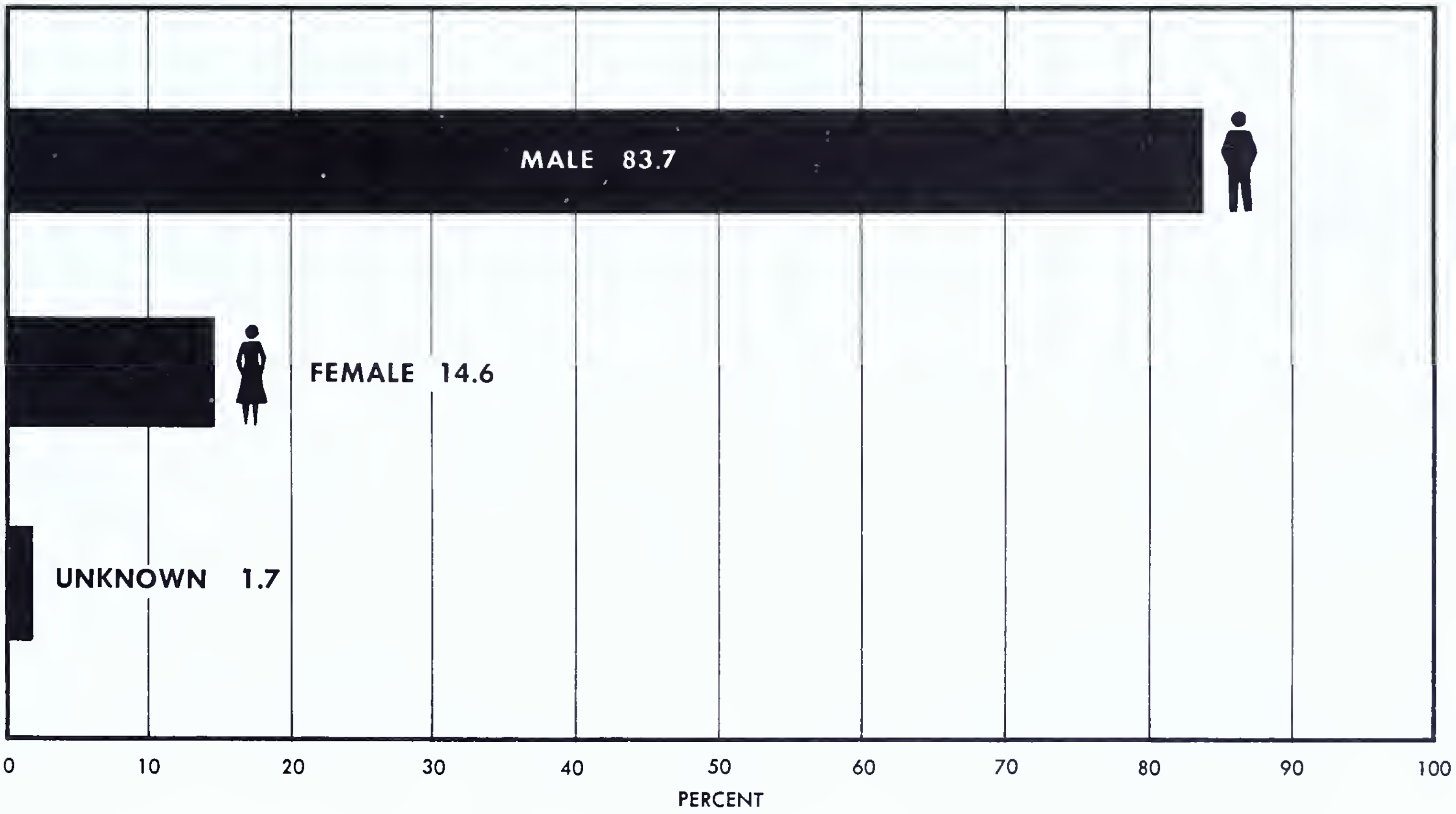


FIG. III-L

PASSENGER CAR ACCIDENT INVOLVEMENT BY AGE OF DRIVER

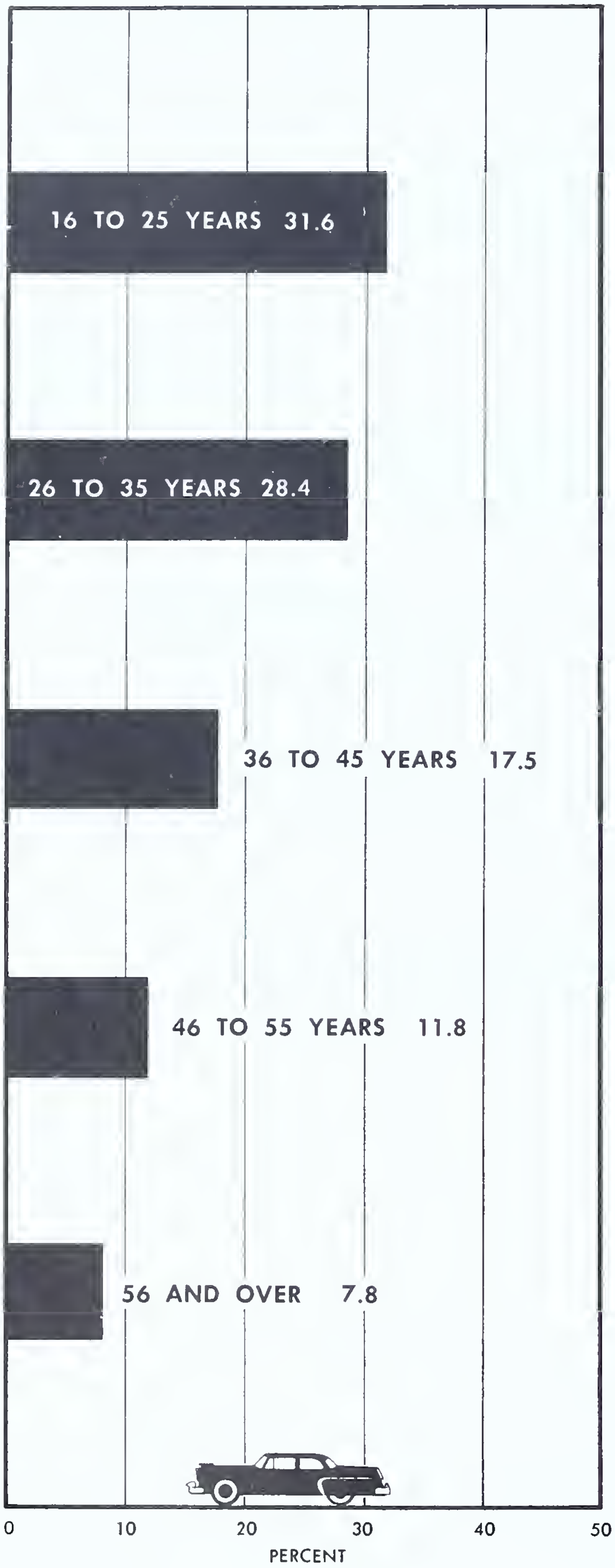


FIG. III-M

TRUCK ACCIDENT INVOLVEMENT BY AGE OF DRIVER

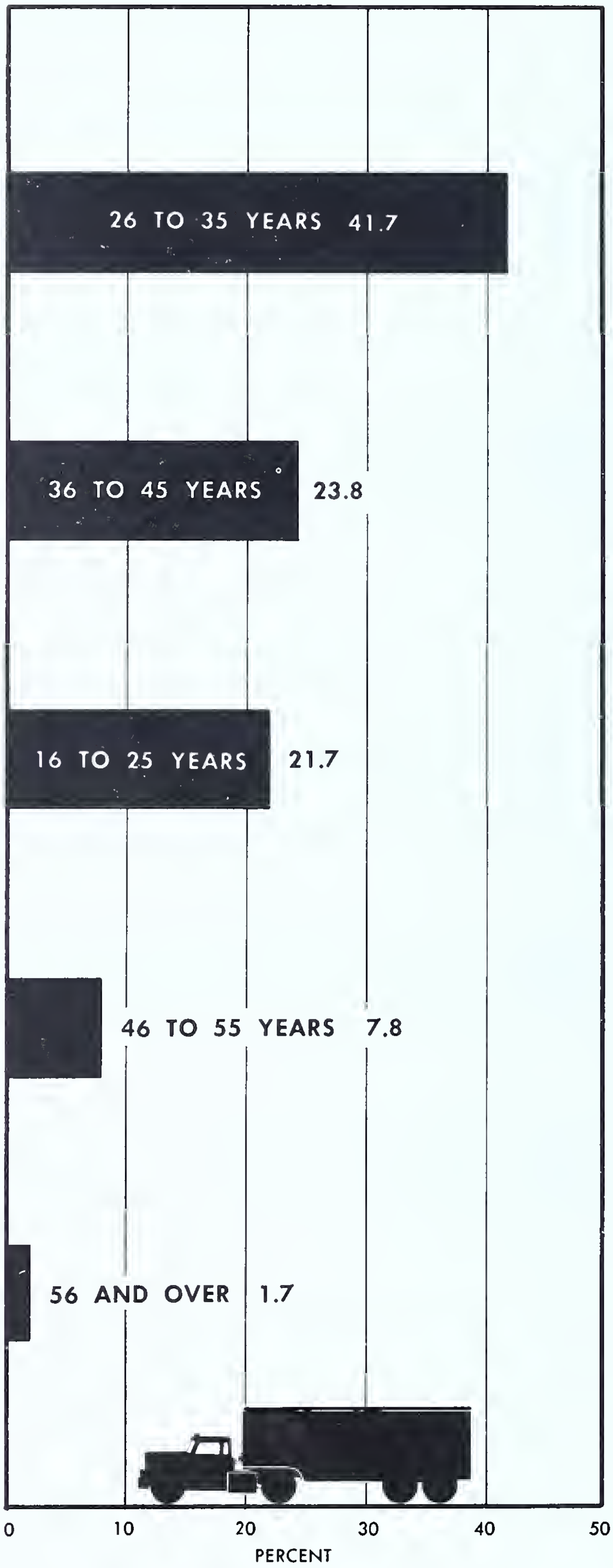


FIG. III-N

PASSENGER CAR ACCIDENT INVOLVEMENT BY ESTIMATED INITIAL SPEED

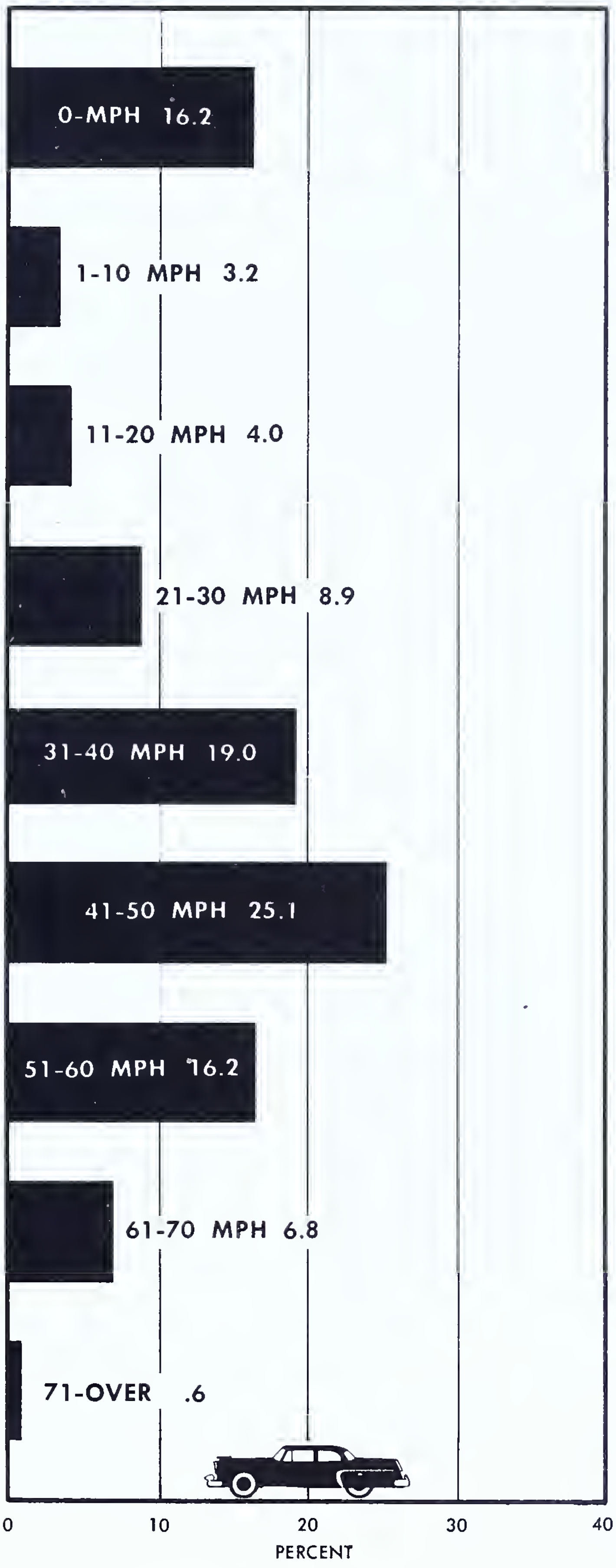
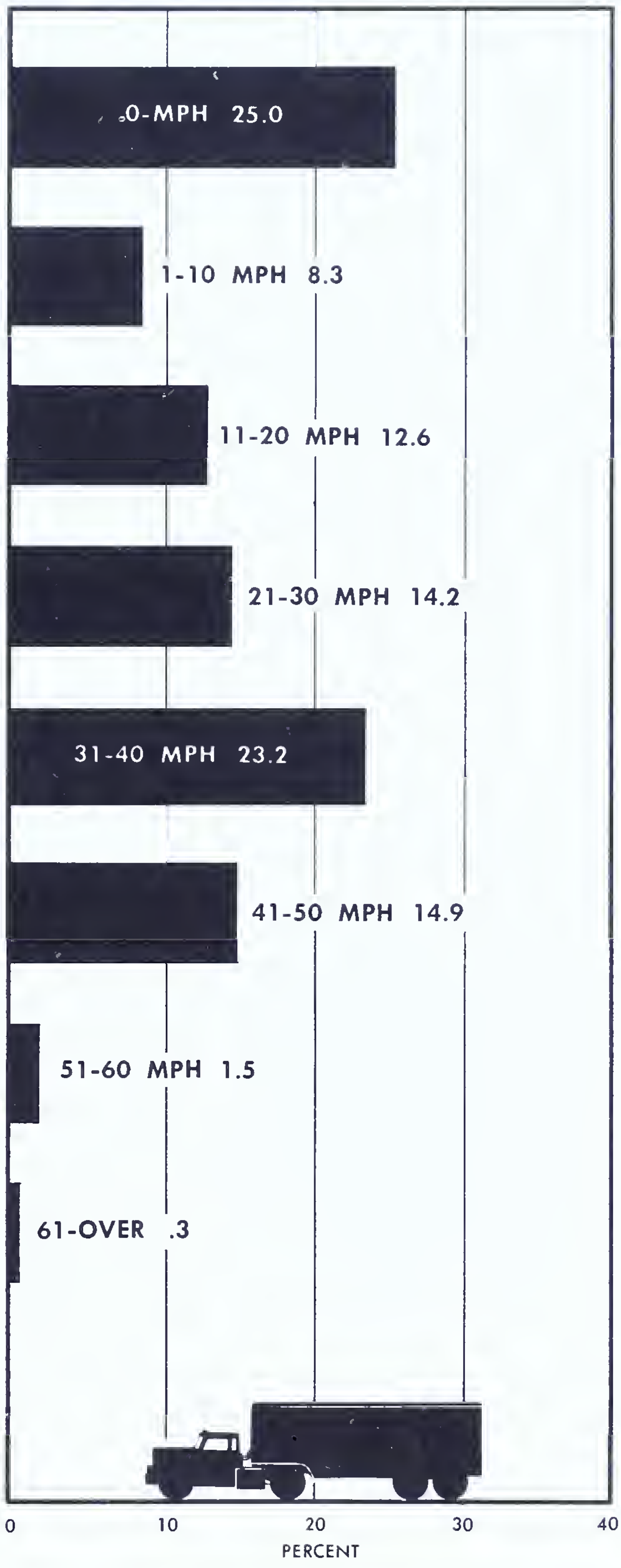


FIG. III-O

TRUCK ACCIDENT INVOLVEMENT BY ESTIMATED INITIAL SPEED



ANALYSIS OF LIGHT CONDITIONS The major role of light conditions in the accident picture is their effect on driving visibility. Light conditions, however, also influence traffic density. Daylight, generally, has higher traffic density than does night or twilight.

1. *Vehicle Involvement Frequency:*

More vehicles were involved in accidents under daylight conditions than under any of the other light categories. Of the 10,888 vehicles involved in accidents during the 12 years under consideration 5,928 or better than 50% were involved under daylight conditions.

2. *Vehicle Involvement Rate*

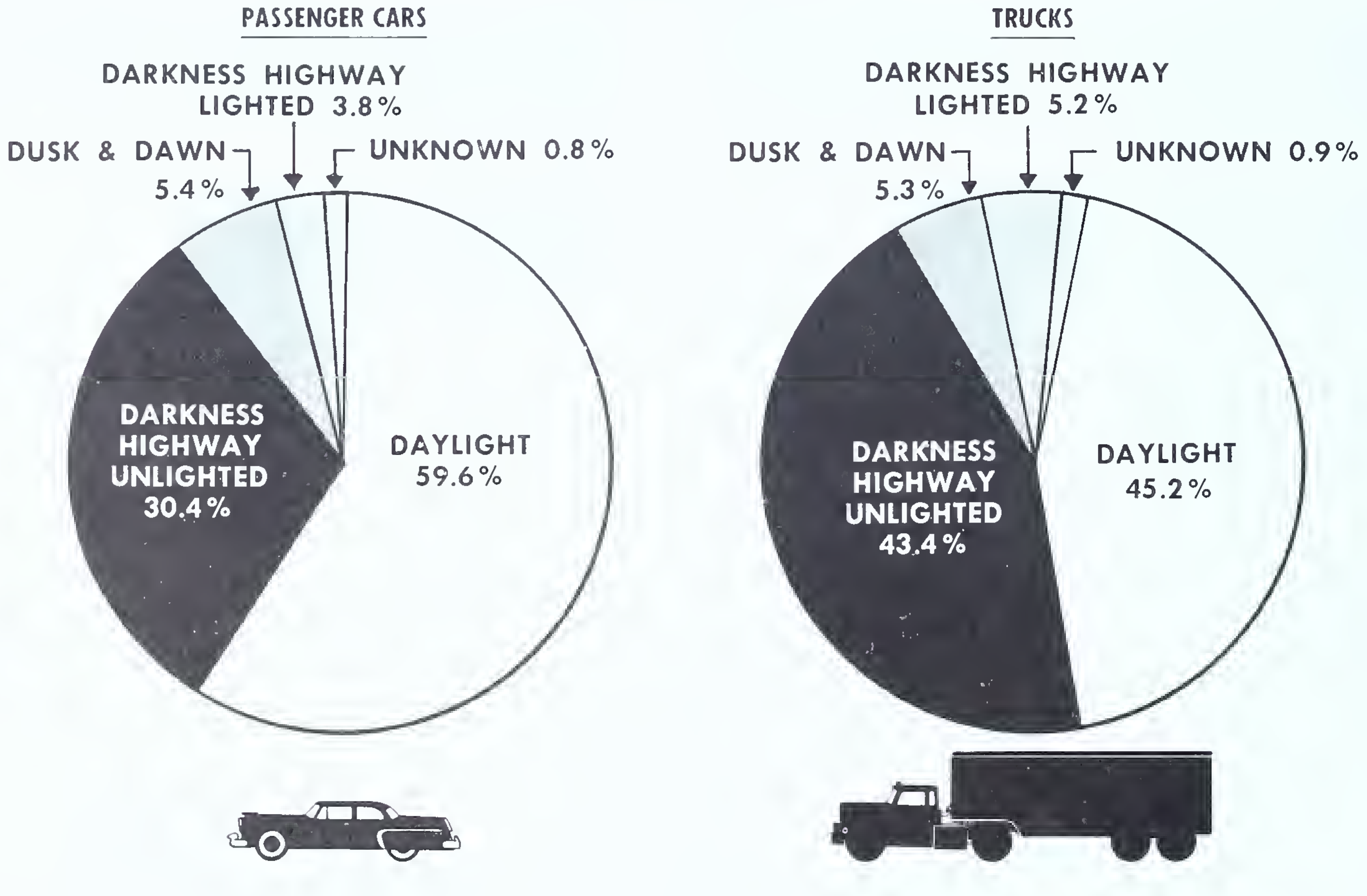
From the work of the field survey team's vehicle traffic counts under the various light conditions, it has been found that Turnpike traffic distribution during 1952 ran approximately 60% daylight and 40% night plus dusk and dawn. The application of these percentages to the 1952 vehicle miles traveled data, and the 1952 vehicle involvement data has resulted in a Night-Dusk and Dawn vehicle involvement rate of 2.5 vehicles per million vehicle miles traveled, and a Daylight rate of 2.3 vehicles involved per million vehicle miles.

It is seen that the more or less "ideal" light condition (Daylight) has only a slightly better vehicle involvement rate overall than the less ideal light conditions of Night-Dusk and Dawn. It can be concluded, therefore, that the broad categories of day vs. night have little effect on

FIGURE III-P

Percent of Vehicle Involvement in Accidents by Light Conditions

(1941-1952)



the rate with which vehicles are involved in accidents.

3. *Light Conditions and Driver Behavior:*

While vehicle involvement in accidents appears to be fairly proportional to exposure, (as indicated by the vehicle involvement rates) significant relationships were discovered between the different light conditions and various other factors. The relationships between light conditions and driver behaviors are pointed out in Table III-1. Here it can be seen that accidents were significantly related to different driver behaviors even though involvement rates were approximately equal.

Passenger car driver Failure to Cope with Road Conditions is seen to be disproportionately high under Daylight conditions. Truck Daylight accidents, on the other hand, show no relationship to specific driver behavior. The significant relationship found for passenger car drivers is attributable to a large extent, at least, to the traffic volume. For example, driver failure to control his vehicle on a wet or icy highway with the higher daylight traffic volume is more likely to result in a collision than would the same failure under the relatively lighter traffic volume of night time.

Both passenger car and truck Asleep accidents were higher than chance expectancy under conditions of Darkness Highway Unlighted. The complexity of the Asleep category is readily apparent. However, it is to be expected that natural living habits cause night drivers in general to experience fatigue more than those taking on the driving task during the daylight hours. These facts coupled with poorer visibility, undoubtedly contribute to the high frequency of night time Asleep accidents.

Passenger car driver Failure to Avoid Objects in Road and Misperception were also disproportionately high under Darkness Highway Unlighted conditions. Both of these behaviorial factors are primarily a function of reduced visibility. While an object in the path of a vehicle on a high speed highway undoubtedly comes as a surprise, the surprise effect is compounded by the poorer visibility conditions of night time driving. The failure of this category to be significantly high for trucks may be accounted for by the relative heaviness and road clearance of trucks as compared to passenger cars. Trucks may encounter as many objects in the road as do passenger cars; however, they may be able to pass over them safely and due to their weight may be

TABLE III-1

Behavioral Areas of Higher than Expected Accident Frequency by Light Conditions**

(1952-1953 Data)

Light Conditions	Passenger Cars	Trucks
Daylight	Failure to Cope With Road Conditions	—
Darkness Highway Unlighted	Asleep Failure to Avoid Objects in Road Misperception	Asleep
Darkness Highway Lighted	Illegal and Unsafe Actions Misperception	—

***Contingency tables containing raw data will be found in the appendices for each table presented in Chapters II and III.*

involved in proportionately fewer accidents. For example, the striking of a box or tire lying in the roadway would probably be less disastrous to a large truck than to a passenger car. Perhaps another plausible reason is the fact that the truck drivers travel at lower speeds and, with greater driving skill generally are better able to handle their vehicles when encountering objects in the road.

Similarly, Misperception, as was noted in Chapter II, is primarily a function of a failure on the part of the driver in judging rate of closure (in addition to deficiencies in visibility). Truck Misperception accidents, however, approximate chance frequency under this light condition.

Darkness Highway Lighted (main line of highway passing gas stations, etc.) truck accidents revealed no relationship to the various driver behavior categories. Passenger car accidents resulting from Illegal and Unsafe Actions and Misperception were higher than expected under this light condition.

As is mentioned elsewhere in this report, the light condition category referred to above (Darkness Highway Lighted) is restricted to gas station areas, interchange areas and tunnel approaches and portals. The deviations considered here, are likely a function of "place" rather than light condition.

In support of this view is the fact that the majority of all gas station and interchange accidents (regardless of light conditions) resulted from Illegal and Unsafe Actions. It is reasonable to believe this situation is aggravated at night by the poorer visibility and light contrasts.

The role of Misperception in Darkness Highway Lighted accidents requires further research for final resolution. However, the nature of these lighted areas does account, to some extent, for this relationship. The more complex and more dense traffic conditions of lighted areas and the light contrasts generally call for more "judgments" or "decisions" on the part of drivers than does the main line normal roadway.

4. *Further Significant Relationships:*

DAYLIGHT

Daylight represents the most ideal light condition from the standpoint of visibility. However, as has been mentioned, light conditions have an influence on other elements of the accident picture. One important effect of light conditions is the apparent influence on exposure (vehicle miles driven). Tests indicate that daytime traffic is generally 50% heavier than night time traffic on the Turnpike. While the vehicle involvement rates of day vs. night are approximately the same, the effect of added daytime exposure and traffic density in combination with the better visibility and the resultant behavioral factors (covered in Chapter II) give significant daytime relationships as discussed below. Although the proportionalities of vehicle miles driven, behaviors, etc., or causes of these relationships are not always discernible, they serve to point up facets of future remedial research.

The following table points up the important relationships between daylight conditions and each of the related accident factors in the same manner as Table III-1 highlighted the relationships of each of the light conditions to the human or vehicular factors which precipitated accidents. The accident factors listed in the left hand column of the table include not only the related accident factors, previously graphed in this chapter, but also the other environmental conditions found to be related to daylight accidents. The areas of vehicle involvement which were higher or lower than would normally be expected on the basis of the marginal distribution of the data are presented for both passenger cars and trucks. The table thus facilitates the comparison of passenger car vs. truck involvements as well as the relationships found among the various factors. This same basic plan will be followed throughout the environmental analysis.

TABLE III-2

Significant Relationships Between Daylight Conditions and Various Accident Factors (1941-1952)

Accident Factors	Passenger Cars		Trucks	
	*High	Low	High	Low
How Vehicle Was Involved	Medial Strip	Parking, Rear End, Overturning	Medial Strip Running Off Road Sideswiping	Parking
Day of Week	—	Sunday	—	—
Place of Occurrence	Gas Station	—	—	—
State of Registration	Out of State	—	—	—
Sex of Driver	Females	—	—	—
Age of Driver	46 or older	16-25	56 & over	26-35
Estimated Initial Speed	50-60 MPH	0-MPH	—	—
Roadway Condition	—	Ice	Snowy	—
Roadway Element	Straight Down	Straight UP	—	—

**High-Low:* *Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

While the areas of lower than expected frequency are included in the above table they are presented primarily as a point of interest, major emphasis being placed on the areas of significantly higher frequency.

How Vehicle Was Involved: Medial strip involvements were disproportionately high for both passenger cars and trucks during Daylight. As was pointed out in Chapter II, a significantly high number of medial strip accidents were precipitated by the driver's Failure to Cope with Road Conditions. Traffic density likely plays a major role in these deviations. A vehicle which crosses the medial strip under the relatively heavier traffic conditions of daytime driving has more chance of being involved in a collision than would a vehicle which crosses the medial strip during the relatively lighter traffic conditions of night time or early morning hours.

A disproportionately high number of trucks were involved in running off roadway and sideswiping accidents during Daylight. Running off roadway accidents are basically similar to medial strip accidents in that both involve the vehicle leaving the main road course. Sideswiping accidents, also are not entirely disassociated from these accidents. Despite the similarity in the nature of the accidents, however, they were precipitated by different factors in a significantly high number of cases. Truck running off roadway accidents were found to be significantly high as a result of Vehicle Failures while truck sideswiping accidents were related significantly to Illegal and Unsafe Actions. Here again, the higher traffic volume during daylight hours plays an important role in these significant deviations.

Place of Occurrence: A significantly high number of passenger cars were involved in accidents in gas station areas (main line accidents in gas station areas) during Daylight conditions. Gas station areas represent a unique section of highway in that here are found more erratic traffic patterns than are common to the Turnpike generally. It is interesting to note that truck involvement shows no relationship to place of accident occurrence under Daylight conditions. As in the other cases, the increased activity in and out of gas stations during daylight hours is at least one of the predominant factors in this significance.

State of Registration: A disproportionately high number of out-of-state drivers were involved in daytime accidents. While base line (vehicle miles driven) data relative to this deviation is not available at the present time, it is not unlikely that a disproportionate percentage of out-of-state vehicles were on the road during the daytime. This assumption is fortified to some extent by the lack of significant behavorial differences between out-of-state vs. in-state drivers (Chapter II) indicating that this deviation is attributable primarily to exposure.

Sex of Driver: A significantly high number of women were involved in accidents during Daylight conditions. General field observations of the Turnpike indicate that a major percentage of total female driving is done during the daylight. In addition accidents involving females were found to be significantly high as a result of Deficiencies in Routine Driving Skills, which in itself has no direct relationship to light conditions, again indicating that the deviation is due primarily to the time of day when most females drive the Turnpike.

Age of Driver: Passenger car drivers 16-25 years old were not involved in a disproportionately high number of accidents under all conditions. They were, however, involved in a significantly low number of accidents during the daytime. On the other hand, a disproportionately high number of passenger car drivers 46 years old and older were involved in accidents under Daylight conditions. Truck drivers 56 years old and older were also involved in a significantly high number of accidents during the daytime.

While certain behavioral differences were found between passenger car driver age groups (Chapter II) they do not appear to be applicable here. Exposure likely plays the important role in these deviations.

Estimated Initial Speed: No factor in the accident picture has received as much public and press attention as speed. The accident precipitating factors related to accidents at the various speeds were covered in Chapter II. The present section of this report will show the relationships between the environmental conditions and the Estimated Initial Speed at which the accidents occurred.

A significantly high number of passenger cars were involved in daylight accidents at speeds of 50-60 MPH. Truck daylight accident involvement, however, showed no relationship to the various stated speeds. Speed tests show that the greatest number of drivers operate within this speed range both day and night. (See Field Survey Appendix) The combination of higher traffic density under Daylight conditions and the number of vehicles traveling in this speed range likely act to result in this deviation.

Roadway Conditions: Truck drivers are apparently less capable of avoiding accidents on snowy roadway during the high traffic conditions of daytime than they are under the lighter traffic conditions of night time driving. A significantly high number of trucks were involved in snowy roadway accidents under Daylight conditions.

Roadway Element: A disproportionately high number of passenger cars were involved in accidents on straight down roadway during Daylight conditions. A large portion of Straight-Down accidents were the result of vehicle failures. It appears logical that these vehicle failures were more likely to result in accidents under the heavier traffic conditions of daytime driving than during the darkness hours.

Summary: Daylight activity on the Turnpike is appreciably higher than the night time and twilight hour activity. This activity takes place under better visibility conditions when, in general, the driver should be at the peak of his ability. In spite of better visibility and setting for better driver condition the greatest total number of accidents occur under Daylight conditions at a rate only slightly better than the night time rate.

It is evident that these more favorable factors found present in daylight driving cannot compensate for such human behavior as driver failure to cope with road conditions. In addition, the better conditions do not support the driver in his driving task to the point where his failures fall far below that of the poorer visibility conditions.

TABLE III-3

Significant Relationships Between Darkness—Highway Unlighted and Various Accident Factors (1941-1952)

Accident Factors	Passenger Cars *High	Passenger Cars Low	Trucks High	Trucks Low
How Vehicle Was Involved	Parking, Rear-End, Overturning	— —	Fires —	Medial Strip Sideswiping
Day of Week	Friday Sunday	—	—	—
Place of Occurrence	Within Tunnel	—	—	—
State of Registration	In-State			—
Sex of Driver	—	Females	—	—
Age of Driver	16-25 years	46 years and over	26-35 years	56 years and over
Estimated Initial Speed	0-M.P.H.	—	31-40 M.P.H.	1-10 M.P.H.
Roadway Condition	Ice	—	—	Snowy
Roadway Element	Straight Up	Straight Down	Straight Up Curved Up Curved Down	Straight Level

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

Aggravating this situation is the increased demand on the daytime driver created by increased traffic volume and density.

DARKNESS HIGHWAY UNLIGHTED

Darkness Highway Unlighted visibility conditions are accepted to be less favorable than Daylight conditions. In addition, traffic density and exposure are in general, lower than under daylight as discussed previously.

Table III-3 points up significant relationships with respect to Darkness-Highway Unlighted.

How Vehicle Was Involved: Passenger car parking, rear-end, and over turning involvements and truck fire involvements were significantly high under conditions of Darkness Highway Unlighted.

Stopped, stopping and parked accidents were found to be significantly related to Illegal and Unsafe Actions. The effect of visibility on the hazards of parking along the Turnpike are self evident. A parking malpractice, hazardous at any time, is even more hazardous under the relatively poorer visibility of night time.

The relationship of rear-end collisions to the driver Falling Asleep, and driver Misperception is an aid in resolving the relationship between high passenger car rear-end collisions and Darkness Highway Unlighted conditions. Perception is basically a function of visibility. Asleep in addition to being significantly related to rear-end collisions was also found to be related to Darkness Highway Unlighted conditions. While the act of a driver falling asleep almost invariably results in accidents under any light condition, propensity to fall asleep is by its very nature expected to be highest at night.

Overturning as it is dealt with in this report covers vehicles which are involved in overturning accidents without striking another vehicle. The disproportionate number of these involvements under Darkness Highway Unlighted conditions may be the result of the drivers inability to detect embankments, culverts, or abutments. An action on the part of the driver resulting in an overturning accident under darkness conditions might have been classified as a collision accident under the heavier traffic conditions of daylight. However, better visibility conditions might have afforded the driver an avenue of escape thus avoiding the overturning accident.

For both passenger cars and trucks, fires are primarily the result of Vehicle Failures. In view of the analysis of fire accidents in Chapter II page 52, the disproportionate number of truck accidents involving fire requires further research for final resolution.

Day of Week: A disproportionate number of passenger car drivers were involved in accidents on Fridays and Sundays under conditions of Darkness Highway Unlighted. These two deviations appear to correspond with the logical pattern of weekend trips. While basic differences may exist between weekend and week day drivers the influence of increased exposure on weekends along with the general living habits over weekends tending toward fatigue, cannot be ignored.

Place of Occurrence: A significantly high number of passenger cars were involved in accidents within tunnels during Darkness Highway Unlighted conditions. It should be remembered, however, that main line normal highway alone accounted for better than 80% of total passenger car involvement in accidents. Within tunnel passenger car involvements amounted to 2.1% of total main line passenger car involvements. Here again the time of occurrence does not lend itself to the alertness demanded of drivers in the tunnels. That is, the main factor here is quite likely driver condition, rather than one of visibility.

State of Registration: In-State passenger car drivers were involved in a significantly high number of Darkness Highway Unlighted involvements. Here again, exposure appears to play a major role in this deviation. No differences in driver behavior were uncovered which would contribute to a deviation of this nature.

Sex of Driver: The low frequency of female involvement in Darkness Highway Unlighted accidents is the reverse of what was found for female involvement under Daylight conditions. In view of the significant relationship between accidents involving females and the Deficiencies in Routine Driving Skill behavorial category it would be somewhat illogical to assume that women were involved in a low number of darkness accidents because of superior driving ability. As was pointed out in the consideration of Daylight, a major percentage of female driving is done during the daylight, leaving the percentage of vehicle miles of night time driving low.

Age of Driver: A disproportionately high number of passenger car drivers 16-25 years old and truck drivers 26-35 years old were involved in Darkness Highway Unlighted accidents. Truck driver age was not found to be significantly related to any of the various accident precipitating behaviors. Passenger car drivers 16-25 years old, however, accounted for a disproportionately high number of Asleep accidents.

While the deviation in truck driver's involvement under this light condition can likely be attributed to exposure, and perhaps some lack of rest the significantly high number of 16-25 year old passenger car drivers involved in falling asleep accidents is an important factor in the passenger car deviation. Reference to the discussion of Asleep accidents, Chapter II page 43, and the Occupational Analysis, Chapter II page 73, will provide the reader with the background details of the passenger car deviation under Darkness Highway Unlighted conditions.

Estimated Initial Speed: A significantly high number of parked passenger cars were involved in accidents on the main line section of the highway under conditions of Darkness Highway Unlighted. It is important to point out again that these "parked" accidents did not occur in the service station parking lots, but rather, involved vehicles parked along the main line of the highway.

The significant relationship here corroborates the relationship noted in the discussion of "How Vehicle Was Involved" under Darkness Highway Unlighted conditions, (page 93 of the present chapter).

Parking along the main line of the Turnpike requires strict conformance to good operating procedures; adequate signaling, pulling off far enough onto the berm, etc., under all environmental conditions. An unsafe parking practice during Darkness Highway Unlighted conditions, however, is compounded by the relatively poorer visibility as compared to daylight.

A disproportionately high number of trucks were involved in accidents during Darkness Highway Unlighted conditions at speeds of 31-40 m.p.h. This truck deviation from expected distribution is, at the present time, unexplainable in view of the lack of significant relationship between driver behavior and truck drivers traveling at speeds of 31-40 m.p.h. In addition, exposure does not appear to account for this deviation. The 10 mile pace speed for trucks, as checked by radar fell between 45-55 m.p.h. (See Appendix B).

Roadway Conditions: A disproportionately high number of passenger cars were involved in accidents on icy roadway under conditions of Darkness Highway Unlighted. No relationship was found between truck involvements and the various roadway condition with the exception of the lower than expected number of truck involvements on snowy roadway under Darkness Highway Unlighted conditions.

Although the passenger car involvement deviation is partially attributable to the fact that icy conditions are more prevalent at night it is interesting to note that truck drivers are not as adversely affected by the icy roadway as are passenger cars. The problem of roadway condition is treated more fully in subsequent pages of this chapter.

Roadway Element: While the roadway element factor will be treated in full as one of the major environmental conditions contributing to the driving task, the inter relationships between Roadway Element and Light Conditions are pertinent at this point.

A significantly high number of passenger cars and trucks were involved in accidents on straight up roadway. Accidents of this type are predominantly rear-end collisions resulting from Asleep and Misperception on the part of the driver.

The apparent incongruity between passenger car rear-end collision relationship to Darkness Highway Unlighted conditions and the lack of truck rear-end collision relationship to Darkness Highway Unlighted conditions becomes apparent at this point. (page 93).

A possible explanation of this incongruity can be found in a closer look at rear-end type collisions. Passenger cars were involved in a disproportionate number of rear-end collisions not only on straight up roadway but also on straight level roadway. Passenger cars were most frequently the striking vehicle on straight up roadway, striking other passenger cars as well as trucks. The truck role in rear-end collisions on straight up roadway, conversely, was that of the struck vehicle predominantly and consequently trucks were involved in proportionately less accidents of this type than were passenger cars.

The visibility factor, generally, in straight-up roadway accidents under conditions of Darkness Highway Unlighted is important and will be included in serious remedial research.

In addition to straight up involvements, trucks were also disproportionately involved in accidents on curved up and curved down roadcourse under Darkness Highway Unlighted conditions. The high number of truck driver Asleep accidents under darkness conditions coupled with the significantly high number of truck curved down accidents resulting from driver Failure to Cope with Road Conditions are important considerations in the understanding of these deviations.

Summary: There is generally less activity on the Turnpike during the night and twilight hours than during the daytime. The decrease in activity brings with it a decrease in the number of accidents as compared to daylight, at a rate which is practically the same as the daylight rate.

Visibility is seen to be an important factor in the number of accidents resulting from driver Failure to Avoid Objects in Road and Driver Misperception. At the same time drivers fall asleep disproportionately more often under darkness conditions. These Asleep accidents manifest themselves in overturning and rear end collisions.

The lighter traffic volume and lighter density of night time travel appears to be a counterbalancing factor in maintaining approximately equal vehicle involvement rates day to night.

DARKNESS HIGHWAY LIGHTED

The "Darkness Highway Lighted" category is unique in that it is more a measurement of specific sections of highway than a measurement of the effects of light conditions.

Darkness Highway Lighted areas include the main line of the highway passing gas station areas, interchange areas and tunnel approaches and portals. The fact that the highway was lighted in these areas is secondary in importance to the fact that these lighted sections of the Turnpike have more erratic and generally more dense traffic patterns than the main line normal sections of roadway.

Entering and leaving vehicles in gas station and interchange areas, speed reduction and "bunching" at tunnel approaches and portals result in changes in the basic traffic make-up. The effects of these changes and the human be-

TABLE III-4

Significant Relationships Between Darkness—Highway Lighted Conditions and Various Accident Factors (1941-1952)

Accident Factors	Passenger Cars		Trucks	
	*High	Low	High	Low
How Vehicle Was Involved	—	Running Off Roadway	Stopped, stopping parked	—
Number of Vehicles	3 or more	Single	—	—
Estimated Initial Speed	0-40 m.p.h.	40-Over m.p.h.	1-10 m.p.h.	11-Over m.p.h.
Roadway Element	Straight Level Straight Down	— —	Straight Level	Straight Up Curved Up Curved Down

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

haviors and vehicular conditions which accompanied them are shown in Table III-4.

Summary: The Darkness Highway Lighted areas of the highway present an added burden on the driver's judgmental and perceptual ability. The visibility or light condition factors in these areas, however, play a minor role in the accident picture. While the contrasts involved in moving from a non-lighted to a lighted section of highway may have a small part in Darkness Highway Lighted involvements, major emphasis must be placed on the place of the accident occurrence. Darkness Highway Lighted areas of the Turnpike are restricted to gas station areas, interchange areas and tunnel approaches and portals. These areas generally have more complex traffic patterns as a result of entering and leaving vehicles, than do the other main line sections of roadway.

DUSK AND DAWN

No significant relationships were discovered between Dusk and Dawn conditions and the various human and vehicular factors relative to accidents. Despite this lack of relationship, however, relationships were found to exist between this light condition and the manner in which the vehicles were involved.

Passenger car involvement in running off roadway and tunnel approach and portal accidents were significantly high during Dusk and Dawn conditions. Truck stopped, stopping and parked involvements, also were disproportionately high during Dusk and Dawn.

ANALYSIS OF WEATHER CONDITIONS Weather plays an important role in the overall make-up of the driving task. It affects not only the driver visibility but also the traction of his vehicle as determined by the condition of the roadway. In addition weather has an effect on traffic density and may even influence traffic pattern. Weather directly, or indirectly modifies driver behavior as evidenced by speed studies under various weather conditions.

FIGURE III-Q

Percent of Vehicle Involvement in Accidents by Weather Conditions (1941-1952)

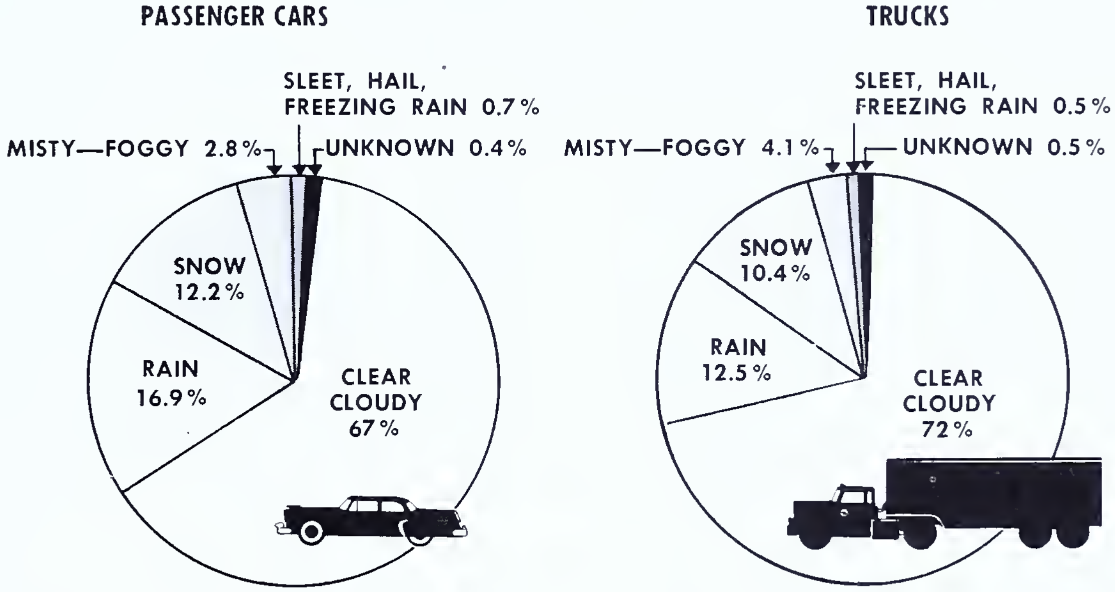
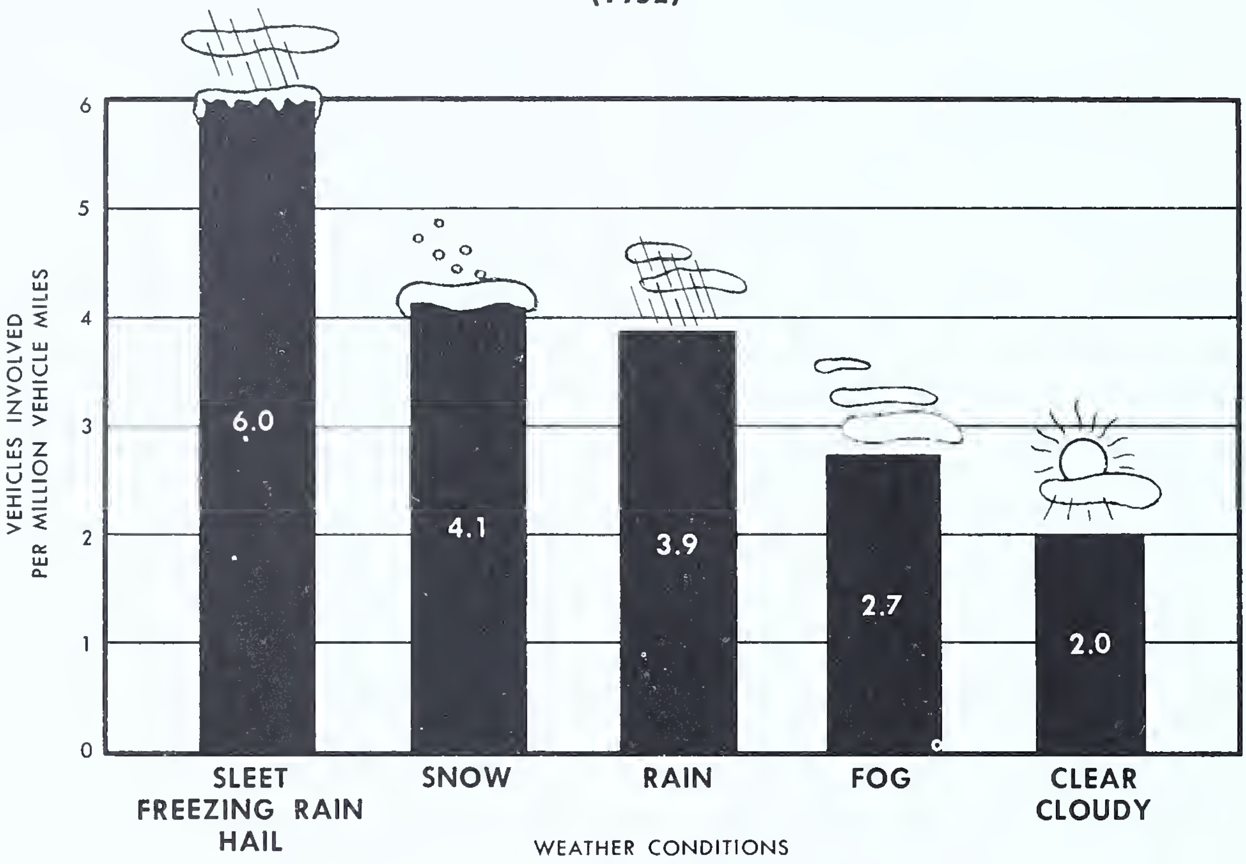


FIGURE III-R

Vehicle Involvement Rate by Weather Conditions (1952)



1. ***Vehicle Involvement Frequency:***

The majority of all vehicles involved in accidents were involved under Clear-Cloudy weather conditions, Raining and Snowing ranking second with Misty-Foggy, and Sleet-Freezing Rain-Hail accounting for only 3.5% of all passenger car involvement and 4.6% of all truck involvement.

2. ***Vehicle Involvement Rate:***

Ratewise, however, as in the consideration of light conditions, those categories with the highest frequency of vehicle involvement in accidents do not necessarily have the highest involvement rate, that is, the highest number of vehicles involved per vehicle mile driven.

The Clear-Cloudy category for example, has the highest accident involvement frequency, but has an accident involvement rate of only 2.0 vehicles involved per million vehicle miles driven, the lowest rate of any category.

Raining weather, on the other hand, with a much lower vehicle involvement frequency than Clear-Cloudy, has an involvement rate of 3.9 vehicles involved per million vehicle miles driven, or almost twice the rate of the Clear-Cloudy category.

The above rate graph, therefore, indicates that drivers on the Turnpike were less capable of avoiding accidents under bad weather conditions (rain, snow, etc.) than they were under the more ideal clear and cloudy conditions.

In addition to the factors which play a part in accidents generally, some factor or combination of factors was present under bad weather conditions which was not, or was to a lesser degree, in operation under ideal weather conditions.

To take an extreme example, the act of slamming on the brakes in certain potential accident situations on dry pavement may, and probably has, served to avoid accidents many times. This same act, however, under raining or snowing conditions will often contribute to the severity of the accidents, and in many cases precipitate the accident itself.

3. *Weather Conditions and Driver Behavior:*

Both passenger car and truck Vehicle Failure accidents were significantly high during Clear-Cloudy weather. In addition passenger car Failure to Avoid Objects in Road and Asleep accidents were also high under Clear-Cloudy conditions.

The significantly high number of Vehicle Failure accidents under Clear-Cloudy weather conditions are easily understood in view of the discussion of Vehicle Failures in Chapter II of this report. A substantial number of the Vehicle Failures are attributed to tire blowouts. Clear-Cloudy weather represents one of the factors conducive to blowouts, i.e., continued high speed over a dry road course, particularly during hot summer months. Such things as prolonged driving under more favorable conditions tend to make this category significantly high.

Passenger car driver Failure to Avoid Objects in the Road was covered in the preceding section of this chapter. The relatively faster speeds traveled by passenger cars during Clear-Cloudy weather may account for the significantly high frequency of failure to avoid objects in road accidents.

The Asleep behavioral category represents no less a complex problem at this point than it did in the consideration of Light Conditions. It is interesting to note that passenger car Asleep accidents were found to be significantly low un-

TABLE III-5

Behavioral Areas of Higher than Expected Accident Frequency by Weather Conditions (1952-1953 Data)

Weather Condition	Passenger Cars	Trucks
Clear cloudy	Vehicle Failures Failure to avoid objects in road Asleep	Vehicle failures
*Raining	Failure to cope with road conditions	Failure to cope with road conditions
*Snow-sleet-freezing rain-hail	Failure to cope with road conditions	Failure to cope with road conditions
Misty foggy	Misperception	

**These passenger car categories are significantly low in asleep accidents.*

der all weather conditions except Clear-Cloudy. For one reason, it is probable that the more adverse weather conditions; Rain, Snow, Sleet, Freezing Rain, Hail and Misty-Foggy serve to keep the driver more alert and attentive to the driving task, thus reducing the tendency to fall asleep. At the same time, rushed week end trips are probably avoided as much as possible when drivers feel they will encounter bad weather.

While truck drivers are not innocent of Asleep accidents, no relationships were discovered between truck Asleep accidents and Weather Conditions.

The passenger car and truck deviations, noted in Table III-5, for Rain, Snow, Sleet, Freezing Rain, Hail are obvious as a result of the characteristics of the table. Inability to Cope With Roadway Conditions would logically be expected to occur almost exclusively under adverse weather conditions with the exception of oil slicks or residual water, snow or ice.

Passenger car driver Misperception accidents were significantly high during Misty-Foggy conditions. Misperception accidents during Misty-Foggy weather are primarily a function of reduced visibility.

Drivers are apparently aware of the hazards of mist and fog as is indicated by the disproportionately high number of passenger car involvements in the 0-30 mph speed range. Despite the passenger car drivers apparent awareness of conditions, however, a disproportionately high number of passenger cars were involved in rear-end collisions during Misty-Foggy weather.

While truck drivers were also involved in a disproportionate number of rear-end collisions during Misty or Foggy weather, no apparent relationships were found for these accidents relative to specific driver behavior.

4. *Further Significant Relationships:*

CLEAR-CLOUDY

Clear-Cloudy weather represents the most ideal weather condition from the standpoint of driving task difficulty, and logically the greatest percentage of vehicle miles are driven under these conditions. It is the category with the highest frequency of vehicle involvement yet the lowest vehicle involvement rate. The following table and discussion will serve to indicate other significant relationships.

TABLE III-6

Significant Relationships Between Clear-Cloudy Weather Conditions and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	—	Medial Strip	Fires	Medial Strip
Number of Vehicles Involved	—	3 or more vehicles	Single vehicle	3 or more vehicles
Estimated Initial Speed	50-70 mph	—	41-50 mph	—
Light Conditions	Daylight	Darkness Highway Unlighted	—	Dusk-Dawn
Roadway Element	Straight up	Curved Down	Straight up	Curved Down

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

How Vehicle Was Involved: A disproportionately high number of trucks were involved in fire accidents under Clear-Cloudy conditions. These accidents were almost exclusively the result of Vehicle Failures. The nature of fire accidents is discussed under Vehicle Failures Chapter II of this report. The relationship between Clear-Cloudy weather and Vehicle Failures as a result of prolonged, high speed driving over hot summer roads was discussed earlier in this chapter. It is seen then that many of the factors contributing to Vehicle Failures generally and fires in particular are found during clear or cloudy weather conditions.

Number of Vehicles Involved: While no significant relationships were discovered between passenger car, Clear-Cloudy weather and the Number of Vehicles Involved in accidents, truck single vehicle accidents were significantly high during Clear-Cloudy weather conditions. While truck Clear-Cloudy involvements were not exclusively Vehicle Failures a significantly high number of trucks were involved in this category. Vehicle Failures were predominantly single vehicle accidents. This fact is probably the predominant factor in truck significantly high single vehicle accidents.

Estimated Initial Speed: A significantly high number of passenger cars in the 51-70 mph speed range and trucks in the 41-50 mph speed range were involved in accidents under Clear-Cloudy weather conditions.

The radar speed checks conducted by the field survey team revealed slight differences in the speeds traveled under the various weather conditions. All vehicles, exhibited a slowing down on snowy and icy roadway.

The less "ideal" weather conditions were found to be related to lower Estimated Initial Speeds than were the Clear-Cloudy conditions.

Exposure seems to play a slight, but not substantial role in these deviations.

In view of the foregoing, the role of the human factor should be more revealing.

Passenger car accidents in the higher speed ranges are attributable primarily to driver Failure to Avoid Objects in Road, Asleep, Inattentiveness and Deficiencies in Routine Driving Skills. Truck accidents in the higher speed ranges resulted primarily as a result of Asleep, Inattentiveness and Misperception. (Chapter II page 76).

The relative driving ease of clear-cloudy weather, especially since it is usually accompanied by dry roads, possibly is contributory to a laxity on the part of the drivers in the behavioral areas listed above, permitting the driver error to be made at a comparatively higher speed than would be found under less favorable conditions.

In addition, it should be noted that these behaviors precipitated accidents at all speeds and were not restricted to high speed accidents only. A driver failure at high speeds, however, does not afford the driver as much "recovery" time as would the same failure at lower speeds, most likely contributing to the above deviations.

Light Conditions: No significant relationships were discovered between disproportionately high truck Clear-Cloudy involvements and the various Light Conditions. A disproportionately high number of passenger cars, however, were involved in Clear-Cloudy accidents during Daylight conditions.

Vehicle Failures play an important part in this passenger car deviation. Table III-5 points out that passenger car Clear-Cloudy involvements were significantly related to not only Vehicle Failures but also Failure to Avoid Objects in Road and Asleep accidents, both of which were found to be significantly related to darkness accidents (Table III-1). While vehicle failures in total, were not related to the various light conditions the combination of Vehicle Failures and Clear-Cloudy conditions resulted in significantly high Clear-Cloudy, Daylight passenger car involvements.

Roadway Element: A significantly high number of both passenger cars and trucks were involved in accidents on straight-up roadway during Clear-Cloudy conditions.

Although no truck driver behavioral categories under Clear-Cloudy conditions appear to tie in with the above deviations, the significantly high number of passenger car accidents under Clear-Cloudy conditions as a result of driver falling asleep most likely is related to this disproportionately high number of straight-up involvements (Table III-5).

Summary: Clear-Cloudy weather conditions account for the greatest percentage of vehicle miles driven over the Turnpike. Clear-Cloudy weather is generally accompanied by dry roadway. The greatest percentage of vehicle miles driven on the Turnpike, therefore, are under the best conditions that can be afforded the driver.

In line with exposure, the greatest number of accidents occur under these "best" conditions. The Clear-Cloudy accident rate, however, is appreciably lower than the rates for other Weather Conditions.

It is strongly indicated that clear and cloudy weather with accompanying dry roadway may be conducive to relaxation and unawareness of the requirements of the driving task on the part of the drivers. While everyone of the accident precipitating behaviors played a part in Clear-Cloudy accidents, these weather conditions were found to be significantly related to driver falling asleep and striking objects in the road—generally related to inattention.

Vehicle Failures also accounted for a disproportionately high number of Clear-Cloudy involvements. This is not surprising, however, when it is remembered that "blowouts", a large percentage of Vehicle Failures, occur most often on hot dry road surfaces as compared to a wet cool roadway.

RAINING WEATHER

Raining weather conditions affect the driver's visibility, the roadway condition and, to some extent, traffic density and vehicle exposure. While Raining weather has a lower vehicle involvement frequency than Clear-Cloudy weather, the vehicle involvement rate is roughly twice the Clear-Cloudy rate.

TABLE III-7

Significant Relationships Between Raining Weather Conditions and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Medial Strip Running Off Roadway	Read End	Medial Strip	Fires
Number of Vehicles	Single Vehicle	2 Vehicles	3 or More Vehicles	2 Vehicles
Estimated Initial Speed	41-50 mph	—	—	—
Roadway Element	Curved Level Curved Down	Straight Up Straight Down	Curved Down	Straight Up

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

How Vehicle Was Involved: A significantly high number of passenger cars were involved in medial strip, and running off roadway accidents under Raining weather conditions. Truck medial strip involvements were also disproportionately high for this weather category. Both medial strip and running off roadway passenger car accidents were seen to be related to driver Failure to Cope With Road Conditions. (Chapter II page 69). This same behavorial factor is, naturally enough, significantly related to both Rainy and Snowy weather conditions.

Although truck medial strip involvements revealed no significant relationships to a specific driver behavior the Failure to Cope With Road Conditions category likely contributed to this deviation.

Number of Vehicles: A disproportionately high number of passenger cars were involved in single vehicle accidents during Raining weather conditions. Truck three or more vehicle involvements were significantly high during Raining weather.

Single vehicle accidents were found to be related to a number of behavioral factors (Chapter II page 77). Failure to Cope with Road Conditions, however, was likely the major factor in the significantly high number of passenger car single vehicle involvements during Raining weather.

Illegal and Unsafe Actions on the part of truck drivers in combination with the roadway condition contributed to the disproportionate number of truck three or more vehicle involvements during Raining weather.

Estimated Initial Speed: It was found that passenger car drivers tend to travel at slightly lower speeds during Raining conditions. The radar speed checks revealed no slowing down on the part of truck drivers, however. (See Appendix B).

The differential between passenger car Clear-Cloudy speeds and passenger car Raining weather speeds, as measured by radar, were not as great as was indicated by the officers' Estimated Initial Speed at the time of the accident. While the vehicle's speed at the moment the accident situation became apparent may actually, in many cases, have been lower than the vehicle's normal speed there may have been some downward shading of the speed as stated by the driver.

A significantly high number of passenger cars were involved in accidents at Estimated Initial Speeds of 41-50 mph. No relationship was discovered between truck driver's Estimated Initial Speeds and Raining weather accidents.

Roadway Element: A disproportionate number of Raining weather vehicle involvements occurred on curved roadway. Passenger car Raining weather involvements were significantly high on curved level and curved down highway; trucks on curved down highway.

Passenger car curved level and curved down accidents resulted disproportionately often from driver Failure to Cope With Roadway Conditions and Deficiencies in Routine Driving Skills. It is not surprising to find driving skill deficiencies highlighted by the combination of rainy weather and curved roadway.

Truck accidents on a curved down roadway resulted disproportionately often from driver Failure to Cope With Road Conditions. It is possible that these failures would be classified Deficiencies in Routine Driving Skills were sufficient information contained in the accident reports.

Summary: Rainy weather accounts for the second greatest number of vehicle miles driven. The second greatest number of accidents occurred under this Weather Condition at a rate about twice that of Clear-Cloudy weather.

The rainy weather driver is confronted with driving problems not generally found under clear-cloudy conditions: lower visibility, as a direct result of the rain and spray from other vehicles, in addition to lower vehicle traction.

While drivers are apparently aware of the increased demands of the driving task, as indicated by the lower estimated initial speeds at which the accidents occur, driver failure to fully recognize the task at hand and driver inability to handle his vehicle once involved in the situation that resulted in an accident appear to be the predominant factors in these rainy weather accidents.

SNOW-SLEET-FREEZING RAIN-HAIL

Sleet; Freezing Rain; and Hail have been grouped with Snowy weather conditions for purposes of this analysis. All four of these weather conditions affect the drivers visibility, the roadway condition, traffic density and vehicle exposure.

Sleet; Freezing Rain; and Hail involvements accounted for only 0.7% of total passenger car involvement and 0.5% of total truck involvement in accidents. Snowy weather, however, accounted for 12.2% of passenger car and 10.4% of truck involvement.

All of these conditions have higher vehicle involvement rates than either the Clear-Cloudy or Raining categories. Sleet; Freezing Rain; and Hail have the highest vehicle involvement rate of any weather condition category (6.0 per million vehicle miles). Fortunately these conditions account for a very minor percentage of total driving conditions.

TABLE III-8

Significant Relationships Between Snow-Sleet-Freezing Rain and Hail Weather Conditions and Various Accident Factors

(1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Medial Strip	—	Medial Strip Sideswiping	Fires
Number of Vehicles	3 or More	Single Veh.	—	Single Veh.
Estimated Initial Speed	21-40 mph	40-Over mph	1-20 mph	30-Over mph
Age of Driver	—	—	46-55 age	16-25 age
Light Conditions	Darkness Highway Unlighted	Daylight	—	—
Roadway Element	Straight Down Curved Up	Straight Level	Curved Up Curved Down	Straight Up

*High-Low: *Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

How Vehicle Was Involved: Medial strip accidents occurred disproportionately more often under conditions of Snow-Sleet-Freezing Rain and Hail. In addition truck sideswiping involvements were significantly high under these weather conditions.

Driver Failure to Cope With Road Conditions was most likely the prime precipitating factor in the significantly high medial strip involvements. The combination of poor visibility, poor roadway conditions and illegal and unsafe actions on the part of truck drivers resulted in significantly high truck sideswiping involvements under Snow, Sleet, Freezing Rain and Hail conditions. Such Illegal and Unsafe Actions as; passing vehicle on right side, cutting in too quickly after passing and pulling out in front of passing vehicle are potentially dangerous actions under the best of driving conditions. (Table II-1). These same actions, when coupled with poor visibility and poor roadway conditions, are even more hazardous as is evidenced by the accident statistics.

Number of Vehicles Involved: Passenger car involvement in accidents during Snow, Sleet, Freezing Rain and Hail conditions were disproportionately more frequent in the three or more vehicle involvement class. Single vehicle involvements were significantly low for both passenger cars and trucks under these conditions. Multiple vehicle accidents often include an illegal or unsafe action on the part of one of the drivers involved in the accident. The examples of accident precipitating actions cited above are equally applicable here.

Estimated Initial Speed: Here, as in the case of rainy weather, the driver's stated speed was somewhat lower than the normal operating speeds as checked by radar and could be the result of slowing down of drivers while the accident situation was establishing itself.

A significantly high number of the Snow, Sleet, Freezing Rain and Hail involvements occurred in the lower speed ranges. A disproportionate number of passenger car involvements occurred between 21-40 m.p.h. and truck involvements between 1-20 m.p.h. Lower speed range accidents for both passenger cars and trucks were found to be significantly related to drivers Failure to Cope with Road Conditions.

It is worth noting at this point that the reduction in speed in these cases did not prevent these accidents. The reduction in speed did not compensate for the commission of illegal and unsafe actions, driver deficiency in handling his vehicle under these road conditions, or any of the other human failures which contributed to these accidents.

Age of Driver: While a significantly high number of truck drivers in the 46-55 age range were involved in accidents under Snow, Sleet, Freezing Rain, and Hail conditions, passenger car driver age showed no relationship to accidents under these conditions.

The lack of relationship between truck driver age and the various behavioral factors leads to the conclusion that the above deviation is probably the result of chance fluctuation.

Light Conditions: A significantly high number of passenger cars were involved in Snow, Sleet, Freezing Rain and Hail accidents during Darkness Highway Unlighted conditions. The role of Misperception, Asleep, and Failure to Avoid Objects in Road under Darkness Highway Unlighted conditions is pointed out in Table III-1. Visibility, then, in addition to driver failure to cope with the condition of the road is seen to play a part in passenger car involvements under these weather conditions. No significant relationships were discovered between truck involvements and Light Conditions. The visibility factor, however, is inferred in all Snow, Sleet, Freezing Rain and Hail weather conditions accidents.

Roadway Element: A disproportionately high number of passenger cars were involved in accidents on straight down and curved up roadway under Snow, Sleet, Freezing Rain and Hail conditions. Truck involvement, on the other hand, was disproportionately high on curved up and curved down roadway under these weather conditions.

The same general behavioral categories mentioned previously are most likely equally applicable here. It is interesting to note, however, that curved up accidents reveal no relationships to any of the specific behavioral categories.

Truck curved down accidents were significantly related to driver Failure to Cope with Road Conditions. Passenger car straight down accidents were significantly related to Vehicle Failures.

Summary: Adverse weather conditions (snow, sleet, freezing rain and hail) fortunately accounted for the lowest number of vehicle miles driven on the Turnpike. Fortunate because the driving task was discovered to be most difficult under these conditions, as indicated by the accident rates.

Two significant relationships were found under these conditions which were not found in the consideration of rainy weather. Darkness, or visibility, begins to play a part in these involvements. In addition, other vehicles on the road enter the picture to compound the task difficulty as inferred by the significantly high number of multiple vehicle accidents.

The poorer visibility conditions of night time driving which place greater demands on driver judgment and skill under the best conditions, compound the demands under these weather conditions.

The greater demand on driving skill is exemplified by the significantly high number of accident involvements while passing or approaching other vehicles as indicated by the number of multiple vehicle accidents.

MISTY-FOGGY WEATHER CONDITIONS

The role of Misty-Foggy weather in the overall accident picture is related primarily to visibility. It is not unlikely, however, that these conditions also exert some influence over traffic density and vehicle exposure much in the same manner as the other weather conditions.

TABLE III-9

Significant Relationships Between Misty-Foggy Weather and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factor	High	Low	High	Low
How Vehicle Was Involved	Rear End Medial Strip		Rear End Medial Strip	Fires
Place of Occurrence	Gas Station Area			
Number of Vehicles	3 or More	Single Vehicle	3 or More	Single Vehicle
Estimated Initial Speed	0-30 M.P.H.			
Light Conditions	Darkness Highway Unlighted	Daylight	Dusk and Dawn Darkness Highway Unlighted	Daylight

How Vehicle Was Involved: Both passenger cars and trucks were involved in a significantly high number of rear-end collisions and medial strip accidents during Misty-Foggy weather conditions. The poor visibility factor inherent in misty-foggy weather, of course, is self evident. In line with this factor of poor visibility, Misperception accounted for a disproportionately high number of rear-end accidents. (Table II-3).

In addition, truck and passenger car drivers were involved in a high number of rear end collisions as a result of Asleep. Passenger car driver's Illegal and Unsafe Actions also contributed disproportionately to rear-end collisions.

While the above behavioral factors in combination with Misty-Foggy conditions were responsible for a disproportionately high number of rear-end accidents, it should not be forgotten that rear-end accidents occurred under all weather conditions. Cause under any of the various weather conditions can be attributed to the behavioral categories mentioned above. Misperception, for example, can occur on a clear cloudy day as a result of an ambiguity of cues as well as during misty-foggy weather as the result of impaired visibility. This is mentioned as a reminder of the various factors involved in the Misperception category.

Place of Occurrence: Passenger car drivers were apparently less capable of coping with the increased traffic complexity of gas station areas during Misty-Foggy weather conditions. While truck involvements showed no relationship to the various place categories during misty or foggy weather, a significantly high number of passenger cars were involved in gas station area accidents under these conditions.

Number of Vehicles Involved: Misty-Foggy accident involvements were disproportionately often three or more vehicle accidents. Reference to "How Vehicle Was Involved" makes the reason for this deviation self evident. The high number of rear-end collisions and medial strip accidents more or less preclude single vehicle involvements.

Estimated Initial Speed: Truck misty-foggy involvements showed no relationship to a specific speed range. Passenger car involvements, on the other hand, were significantly often lower speed range accidents between 0-30 M.P.H. Any of the precipitating factors found related to the lower speeds (Chapter II, page 76) are applicable to this deviation. Here again is emphasized the fact that faulty driving behavior at any speed can result in accidents.

Light Conditions: A disproportionate number of vehicles involved in Misty-Foggy accidents were involved during Darkness Highway Unlighted conditions. Truck Dusk and Dawn involvements were also significantly high during mist and fog.

It is readily apparent that the poor visibility conditions of mist and fog were compounded by the less ideal light conditions.

Summary: Misty-Foggy weather conditions account for a relatively low number of accident involvements. The Misty-Foggy estimated accident rate is practically the same as the Clear-Cloudy rate.

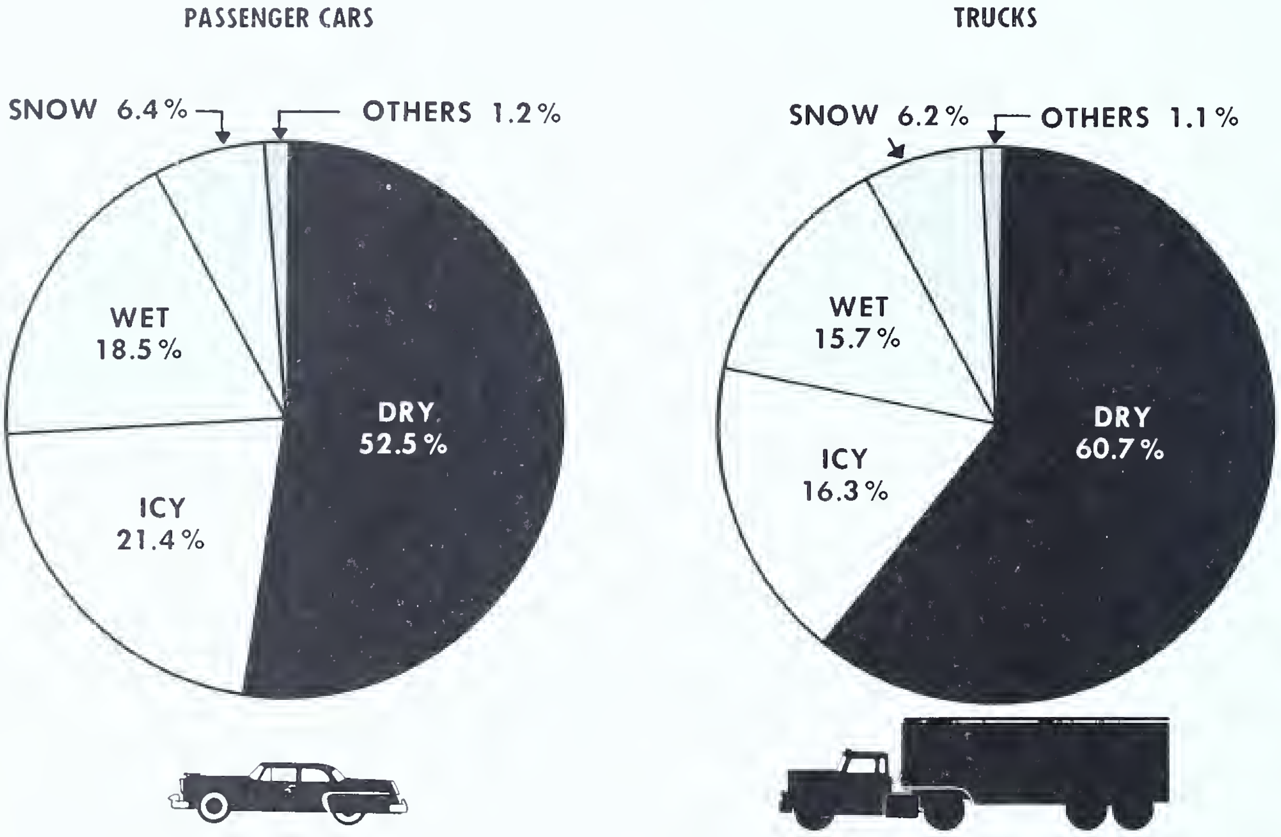
Certainly the driving task under these poorer visibility conditions must be more difficult than the clear-cloudy task. The fact that the accident rates are close indicates that the drivers have been able to take on the problem represented by poor visibility in this case quite well. One indication of the effect of these conditions on the driver is found in the significantly low speed at which these accidents occurred.

As would be expected, darkness added to the drivers burden as evidenced by the significantly high number of accidents under the Darkness Highway-Unlighted category.

ANALYSIS OF ROADWAY CONDITIONS For purposes of this analysis the roadway conditions which existed at the time of accidents were broken down into; Dry, Wet, Snow-Slush and Ice. These conditions affect not only the driver but also the roadway and vehicle elements in the closed loop driver-roadway-vehicle system. In addition, roadway conditions affect the formation of the traffic pattern as well as the vehicle exposure. Visibility is, to some degree, affected by the roadway conditions.

FIGURE III-S

Percent of Vehicle Involvement in Accidents by Roadway Conditions (1941-1952)



1. *Vehicle Involvement Frequency:*

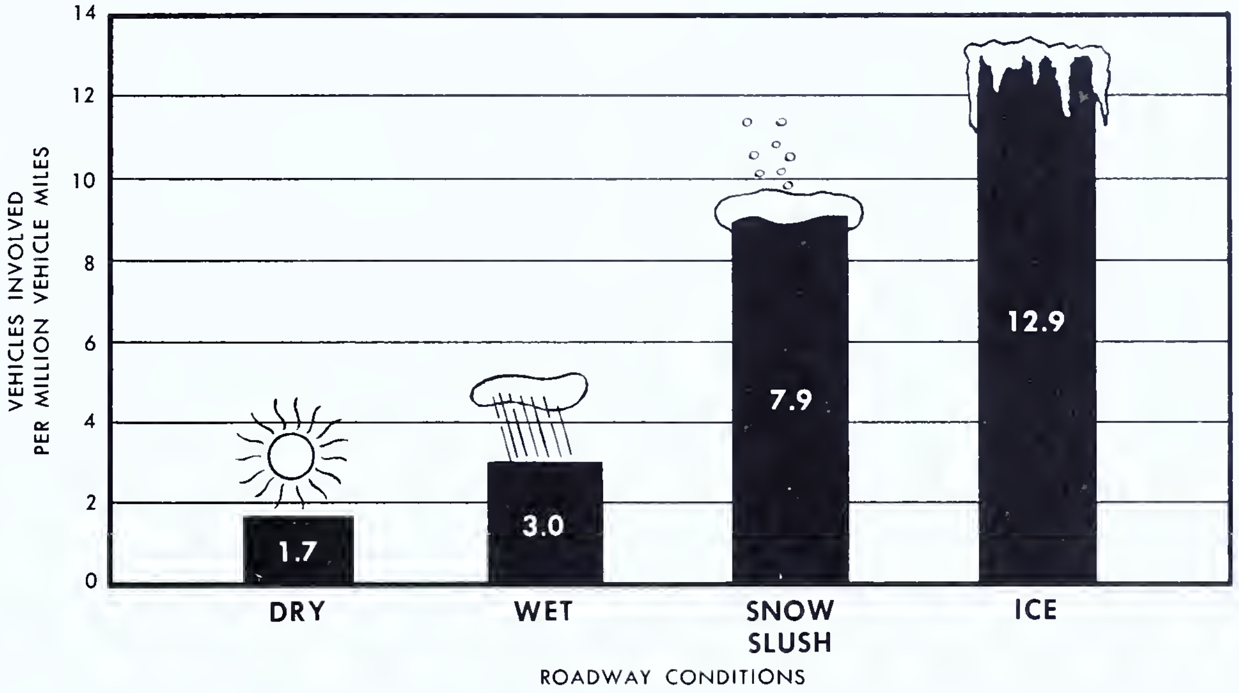
The above charts show the distribution of vehicle involvement in accidents by Roadway Conditions. Better than 50% of all vehicles involved in accidents were involved on dry roadway.

2. *Vehicle Involvement Rate:*

While dry roadway is seen to be the big offender from the standpoint of accident involvement frequency, the computation of involvement rates presents a completely different picture (see Fig. III-T). Dry roadway is seen to be the least difficult roadway condition confronting the driver. Icy roadway represents the most difficult task as determined by the number of vehicles involved in accidents per million vehicle miles traveled.

FIGURE III-T

Vehicle Involvement Rate by Roadway Condition
(1952)



3. *Roadway Conditions and Driver Behavior:*

TABLE III-10

Behavioral Areas of Higher than Expected Accident Frequency by Roadway Conditions
(1952-1953 Data)

Roadway Conditions	Passenger Cars	Trucks
Dry	Vehicle Failures, Failure to Avoid Objects in Road Asleep, Inattentiveness, Illegal and Unsafe Actions	Vehicle Failures
*Wet	Failure to Cope With Road Conditions	Misperceptions
*Snow-Slush	Failure to Cope With Road Conditions	Failure to Cope With Road Conditions
*Ice	Failure to Cope With Road Conditions (All other categories lower than expected)	Failure to Cope With Road Conditions

**These categories are significantly low in passenger car asleep accidents.*

Both passenger car and truck Vehicle Failure accidents were significantly high on Dry Roadway. While the remainder of truck Dry Roadway accidents approximate chance expectancy for the various behavioral categories, passenger car Dry Roadway accidents revealed additional significant relationships. A disproportionately high number of passenger car Dry Roadway accidents resulted from: Failure to Avoid Objects in Road, Asleep, driver Inattentiveness and Illegal and Unsafe Actions.

Vehicle Failures here, as in the consideration of Weather Conditions, occurred disproportionately frequently under the "ideal" environmental conditions. Dry Roadway is, of course, related to Clear-Cloudy weather conditions as opposed to Raining, Snowing, etc. The same factors conducive to blowout accidents, therefore, apply to dry roads as applied to clear-cloudy weather conditions.

Similarly, the significantly high number of passenger car Failure to Avoid Objects in Road accidents can be traced to the same basic causes discussed under Clear-Cloudy weather conditions. A combination of passenger car higher speed and relatively light weight and road clearance, as compared to trucks, may account for the importance of this behavioral category in passenger car accidents. As was mentioned previously, the appearance of an object in the road on a high speed, express highway represents a surprise element especially when warnings are ignored. The surprise however is compounded or magnified at higher speed travel under good driving conditions at night particularly.

As under the consideration of passenger car accidents during the various Weather Conditions, Asleep, accidents were found to be disproportionately high on Dry Roadway and disproportionately low on all other roadway conditions. The causal factors relating to these Asleep accidents can also be applied to the Inattentiveness categories. The more difficult driving conditions of a Wet, Snowy, Slushy or Icy Roadway undoubtedly serve to keep the driver more attentive and alert to the driving task. The ideal roadway condition (Dry) tends toward a false sense of security or complacency.

Passenger car driver Illegal and Unsafe Actions on Dry Roadway logically result in more accidents under conditions of higher traffic volume than the same actions under more adverse roadway conditions when the volume is reduced appreciably. Illegal and Unsafe Actions encompass such action as; improper passing practices, stopping on the highway, unsafe parking practices, U-turns, etc. These actions, while dangerous at all times, are likely to occur more frequently and are potentially more dangerous under conditions of heavier traffic density generally associated with Dry Roadways.

Passenger car accidents on Wet, Snow-Slush, and Icy roadways were higher than chance expectancy as a result of driver Failure to Cope With Road Conditions. Truck Failure to Cope With Road Condition accidents were, on the other hand, higher than expected under Snowy-Slushy and Icy Roadway conditions. Truck driver Misperception accidents were, however, higher than chance expectancy under conditions of Wet Roadway.

These Failure to Cope With Road Condition deviations may not be truly significant relationships but rather a characteristic of the table. It is interesting to note, in this connection, that here, as under adverse weather conditions, drivers were apparently aware of the additional hazards of "bad" roadway conditions. Estimated Initial Speeds were significantly lower under Wet, Snowy, Slushy, and Icy Roadway than under Dry Roadway conditions. Despite these slower speeds, however, medial strip, stopped-stopping-parked, running off roadway involvements were significantly high under these conditions. Trucks were involved significantly more frequently on straight down roadcourse during Snowy or Slushy Roadway conditions and curved down roadway under Icy conditions.

Curved level roadway was related to a high frequency of passenger car Wet Roadway involvements while straight down, curved up, and curved down roadway elements were significantly related to passenger car Icy Roadway involvements.

4. *Further Significant Relationships:*

DRY ROADWAY

As has been stated, Dry Roadway is the most ideal driving condition from the standpoint of rate. A dry road, most likely, takes the least amount of driving skill to negotiate as compared to the other possible roadway conditions.

TABLE III-11

Significant Relationships Between Dry Roadway Conditions and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Overturning Fires	Medial Strip	Fire	Medial Strip
Place of Occurrence	Within Tunnel	Bridges		Tunnel Approach and Portal
Number of Vehicles		3 or more Vehicles	Single Vehicle	2 or more Vehicles
Estimated Initial Speed	51-Over M.P.H.	1-40 M.P.H.	41-50 M.P.H.	1-10 M.P.H.
Roadway Element	Straight Level Straight Up	Curved Down	Straight Up	Curved Down

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

How Vehicle Was Involved: A significantly high number of passenger cars and trucks were involved in fire accidents on Dry Roadway. Passenger cars were also disproportionately involved in overturning accidents. It is interesting to note that medial strip accidents were significantly low on Dry Roadway.

Table II-3, page 69 reveals that both overturning and fire accidents were significantly often the result of Vehicle Failures. The relationship between Vehicle Failures and "ideal" environmental conditions, discussed elsewhere in this report, is highlighted in Table III-10.

In addition to Vehicle Failures, however, passenger car Dry Roadway accidents were found also to be related to driver Failure to Avoid Objects in Road, Asleep, Inattentiveness and Illegal and Unsafe Actions. All of these behavioral categories likely contributed heavily to the disproportionately high number of passenger car overturning accidents on Dry Roadway.

Place of Occurrence: Passenger car within tunnel accident involvements occurred disproportionately frequently on Dry Roadway. This deviation, however, is more a function of the nature of tunnels than a significant deviation. While the roadway within a tunnel may be frequently wet, the nature of the tunnel precludes a snowy and, to a large degree, icy roadway condition.

Number of Vehicles Involved: Truck single vehicle accident involvements occurred disproportionately frequently on Dry Roadway. This deviation is not surprising in view of the disproportionately high number of vehicle failures on dry roadway. Truck vehicle failures generally involve only one vehicle.

Estimated Initial Speed: A significantly high number of Dry Roadway involvements occurred at the higher speed ranges (over 40 M.P.H.). The reader is once again referred to the radar speed check data found in the "Field Survey Appendix" of this report.

While the behaviors shown in Table III-10 were the prime precipitating factors involved in these accidents the actual deviation appears to result largely from exposure. Both the passenger car and truck deviations approximate the limits of the 10 mile pace speed as determined by radar.

Roadway Element: Dry Roadway involvements occurred disproportionately frequently on straight roadway. Both passenger cars and trucks were involved in a significantly high number of straight up accidents. Passenger cars were also involved in a higher than expected number of straight level accidents.

While the relationships between behaviors and the various roadway elements are fully covered later in this chapter, it is pertinent in relation to the above deviations to point out the predominance of Asleep and Misperception behaviors involved in accidents on straight up roadways. Passenger car straight level involvements were similarly related to driver Failure to Avoid Objects in Road.

Summary: By far the greatest number of vehicle miles on the Turnpike were driven on Dry Roadway. Likewise the greatest number of accidents occurred under this condition. Dry roadway, however, had a lower accident rate than any of the other Roadway Conditions.

Dry Roadway accidents were found to be significantly related to Vehicle Failures, Asleep, Inattention, and Illegal and Unsafe Action.

It becomes apparent that in spite of the lowest rate, the best driving conditions that nature affords the driver are not good enough to compensate for errors in driver behavior and vehicle failures.

WET ROADWAY

Reference to Table III-10 reveals a basic difference between the affect of Wet Roadway on passenger car drivers as opposed to truck drivers. As might be expected, a significantly high number of passenger car drivers were involved in accidents on Wet Roadway as a result of Failure to Cope With Roadway Conditions. Truck accidents on Wet Roadway, however, showed no relationship to this behavioral category. A significantly high number of truck accidents on Wet Roadway resulted from Misperception.

In addition to its affect on the driving task generally, wet roadway also likely affects the vehicle exposure. Most drivers prefer to drive under so called "ideal" environmental conditions, consequently some drivers avoid the less favorable roadway conditions including not only wet roadway but also snowy, icy, and slushy conditions.

How Vehicle Was Involved: A disproportionately high number of both passenger cars and trucks were involved in medial strip accidents on Wet Roadway. Passenger cars were also involved in a high number of running off roadway accidents. It will be remembered from Chapter II that both medial strip and running off roadway passenger car involvements were found to be disproportionately often the result of Failure to Cope With Roadway Conditions. Truck medial strip accidents revealed no relationships to any of the specific behavioral categories. It is interesting to point out at this time that passenger car and truck medial strip involvements occur significantly often under each of the, more or less, adverse roadway conditions.

Table II-3, Chapter II further points out

TABLE III-12

Significant Relationships Between Wet Roadway Conditions and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Medial Strip, Running Off Roadway	Rear End	Medial Strip	Fire
Place of Occurrence	Within Tunnel		Within Tunnel	
Number of Vehicles Involved	Single Vehicle	2 Vehicles		
Estimated Initial Speed	41-50 M.P.H.		31-40 M.P.H.	
Roadway Element	Curved Level	Straight Up		

**High-Low:* *Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

that passenger car running off roadway accidents are related to the driver's deficiencies in routine driving skills as well as his failure to cope with the roadway conditions.

Place of Occurrence: While better than 80% of all vehicle involvement occurred on the normal main line section of the highway, a significantly high number of Wet Roadway accidents occurred within tunnels. In so far as snow, slush and ice are rarely found within tunnels, this deviation is not surprising. In addition snowy, slushy, or icy conditions on the roadway outside of tunnels might easily contribute to a wet roadway condition within the tunnel itself.

Number of Vehicles Involved: A higher than expected number of passenger car involvements on Wet Roadway were single vehicle accidents. Truck involvement showed no relationship to the number of vehicles involved. Passenger car driver Failure to Cope With Road Conditions and Deficiencies in Routine Driving Skills frequently resulted in single vehicle accidents, however.

Estimated Initial Speed: Here, as was found in the consideration of Weather Conditions, as the environment category increases in driving task difficulty as measured by vehicle involvement rate, the driver's stated estimated initial speed drops. A significantly high number of passenger car Wet Roadway involvements occurred at Estimated Initial Speeds of 41-50 M.P.H., approximately ten miles per hour slower than under Dry Roadway conditions. The same deviation from Dry Roadway speeds was noted for trucks. A disproportionate number of truck involvements occurred at stated speeds of 31-40 M.P.H. These deviations are difficult to explain in view of the findings of the radar research conducted by the field survey team. Passenger cars were found to slow down but slightly on wet roadway while truck wet roadway speeds were not appreciably different from dry roadway speeds. It is possible that drivers involved in accidents underestimated their speed on the accident report in some cases. Of course it is also possible that the drivers who traveled in these medium speed ranges were the ones who got themselves into trouble. Driver behaviors at the various speeds are covered in Chapter II, Page 76.

Roadway Element: Although truck involvements showed no relationship to the roadway elements, passenger car Wet Roadway accident involvement occurred disproportionately often on curved level roadway. While Failure to Cope With Road Conditions is logically inferred in adverse roadway conditions, Deficiencies in Routine Driving Skills contributed disproportionately to curved level passenger car involvements and could be an important factor in the case of Wet Roadway also.

Summary: Wet Roadway is directly associated with rain and melting snow. In addition wet roads are found occasionally under conditions of clear-cloudy weather as a holdover from rain or snow. This accounts for the slightly lower accident rate for wet roadway as compared to the accident rate under precipitation. It will be remembered that there were 2.5 accidents per million vehicle miles traveled under precipitation conditions and 1.9 accidents per million vehicle miles driven under wet roadway. These compare to a dry pavement rate of 1.1 accidents per million vehicle miles.

The two major factors contributing to the driver task here are the same as those discussed under Raining Weather Conditions: poor visibility, and reduced traction between tire and road surface. Considering these factors it is apparent why these accidents were significantly related to Failure to Cope With Road Conditions and Misperception.

SNOWY AND SLUSHY ROADWAY

As can be seen from Table III-10 Snowy and Slushy Roadway conditions were found to be significantly related to Failure to Cope with Road Conditions. Snowy and Slushy conditions accounted for a relatively low percentage of total passenger car and truck involvement in accidents. The vehicle involvement rate of Snowy and Slushy Roadway was, however, second only to Icy Roadway conditions.

TABLE III-13

Significant Relationships Between Snowy and Slushy Roadway Conditions and Various Accident Factors (1941-1952)

Accident Factors	Passenger Cars		Trucks	
	*High	Low	High	Low
How Vehicle Was Involved	Stopped, Stopping, Parked Medial Strip		Stopped, Stopping, Parked Medial Strip Sideswiping	Fire
Age of Driver	26-35 Age		46-55 Age	16-25 Age
Estimated Initial Speed	21-30 M.P.H.	51-Over M.P.H.	11-20 M.P.H.	31-Over M.P.H.
Number of Vehicles Involved	3 or More	Single Vehicle	2 or More	Single Vehicle
Roadway Element			Straight Down	Straight Up

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

How Vehicle Was Involved: A significantly high number of both passenger cars and trucks were involved in stopped-stopping-parked and medial strip accidents during Snowy or Slushy Roadway conditions. Trucks also were involved in a disproportionately high number of sideswiping involvements under these conditions.

Table II-3, Chapter II points out the significant relationship of stopped- stopping-parked accidents and sideswiping accidents to Illegal and Unsafe Actions on the part of the drivers. While Illegal and Unsafe Actions are dangerous under any roadway condition, the combination of the actions with snowy and slushy roadway resulted in a significantly high number of these involvements.

The medial strip deviation, noted above, resulted primarily from Failure to Cope With Road Conditions.

Age of Driver: A significantly high number of passenger car drivers in the 26-35 age range and truck drivers in the 46-55 age range were involved in accidents during Snowy-Slushy conditions. No clue as to the cause of these deviations was found through reference to driver behaviors at the various age levels. Further, and more specific, research would be required to uncover the true significance and cause of these deviations. It can be assumed, however, that on the basis of the data presently available drivers in these age ranges were less successful in coping with snowy and slushy roadway than were drivers generally.

Estimated Initial Speed: The relationship between the drivers stated speed and the vehicle involvement rate of the specific categories has already been touched upon. Snowy and Slushy conditions are no exception. A significantly high number of passenger cars were involved in accidents under these roadway conditions at speeds of 21-30 M.P.H. Truck 11-20 M.P.H. involvements were also higher than expected for snowy and slushy roadway. Table II-9, Chapter II points out the significant relationship of passenger car 21-40 M.P.H. involvements and truck 11-30 M.P.H. involvements to Failure to Cope With Road Conditions. It appears reasonable to assume that the Failure to Cope With Road Conditions category represents the primary factor in Snowy-Slushy accidents at the various speeds.

Number of Vehicles Involved: A significantly high number of both passenger car and truck involvements on Snowy and Slushy highway were multiple vehicle accidents. Single vehicle involvements were disproportionately low. As was mentioned previously, multiple vehicle accidents generally involved Illegal or Unsafe Actions on the part of one or more of the participants to the accident. The multiplicity undoubtedly contributes substantially to the relatively high vehicle involvement rate of this category.

Roadway Element: No relationship was discovered between Snowy and Slushy passenger car acidents and the various Roadway Elements. It can be assumed, therefore, that each of the different Roadway Elements contributed proportionately to passenger car involvement under these conditions.

Truck involvement, on the other hand, was significantly high on straight down roadway. With the exception of the inferred failure of drivers to cope with snowy and slushy conditions specific reasons for this deviation are difficult to determine.

Summary: The factors in operation on Wet Roadway were also found to be in operation under Snowy and Slushy conditions. Multiple vehicle accidents, however, were significantly related to Snowy and Slushy conditions.

While these accidents were significantly related to Failure to Cope With Road Conditions it is likely that were more data available many of these accidents would be classified under such categories as, Deficiencies in Routine Driving Skills, Illegal and Unsafe Actions and Misperception.

ICY ROADWAY

Icy Roadway was found to have the highest estimated vehicle involvement rate of any Roadway Condition category. Icy Roadway involvements were found to be significantly related to Failure to Cope with Road Conditions. As was the case with other Roadway Condition categories, Icy Roadway likely has an important effect on vehicle exposure. In so far as traffic slows appreciably under this condition, traffic density and traffic pattern are also affected by Icy Roadway conditions.

How Vehicle Was Involved: The types of accidents which occurred on Icy Roadway were substantially the same as those which occurred on Snowy and Slushy Roadway. A significantly high number of both passenger cars and trucks were involved in medial strip accidents on icy roadway. Passenger cars were also involved in a disproportionately high number of stopped-stopping-parked accidents.

The relationship of these specific type accidents to the various driver behaviors has already been pointed out. Medial strip accidents occurred significantly often as a result of Driver Failure to Cope With Road Conditions. Illegal and Unsafe Actions, on the other hand, were the prime causal factors of stopped-stopping or parked accidents.

TABLE III-14

Significant Relationships Between Icy Roadway Conditions and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Stopped-Stopping-Parked Medial Strip		Medial Strip	Fire
Place of Occurence	Bridges	Within Tunnel	Tunnel App. and Portal	Within Tunnel
State of Registration	Out of State	In State		
Number of Vehicles Involved	3 or More	Single Vehicle	3 or More	Single Vehicle
Age of Driver	26-35 Age			
Estimated Initial Speed	11-40 M.P.H.	41-Over M.P.H.	1-30 M.P.H.	31-Over M.P.H.
Roadway Element	Straight Down Curved Up Curved Down	Straight Level	Curved Down	Straight Up

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

In concluding the analysis of How Vehicle Was Involved by Roadway Conditions one point must be stressed. In reviewing this section it will be noted that no significant relationships were discovered between rear-end collisions and any of the various roadway conditions. Rear-end collisions were, however, seen to be significantly low for passenger cars on Wet Roadway. It should not be concluded from this apparent lack of significant relationship that rear end collisions are an unimportant category. Just the opposite is true. The greatest percentage of accidents under any of the Roadway Conditions were rear-end accidents. It is apparent, though, that little, or no, relationship exists between rear-end collisions and the various Roadway Conditions. Any remedial measures directed at rear end collisions can be expected to be equally effective on all roadway conditions.

Place of Occurrence: A disproportionately high number of passenger cars were involved in accidents on major or minor bridges on Icy Roadway, while truck drivers experienced significantly more difficulty at tunnel approaches and portals.

Bridges normally accumulate ice faster and retain it longer than other sections of the roadway. The element of surprise likely enters into the significantly high number of passenger car involvements on icy bridges. Lack of familiarity with the roadway likely plays an important part in this deviation. Further research is required to more accurately pin point the difficulty. It should be noted, however, that of all passenger car Icy Roadway involvements less than 2.5% occurred on bridges (34 passenger cars for the 12 year period 1941-1952).

A similar situation is noted in relation to the significantly high frequency of truck involvements at tunnel approaches and portals. Of all Icy Roadway truck involvements in accidents 6% occurred at tunnel approaches and portals. While most of the behavioral categories covered in Chapter II could account for a deviation of this nature further research would be required to isolate a single or group of driver behaviors which contributed disproportionately.

In actual frequency of both passenger car and truck involvements the main line normal section of roadway overshadows all other Place categories.

State of Registration: Out-of-state passenger car drivers contribute disproportionately to the Icy Roadway accidents. In relation to this deviation it is pointed out in Chapter II that Pennsylvania passenger car drivers were involved in significantly fewer accidents attributable to Failure to Cope With Road Conditions than were out-of-state drivers. It is further pointed out that this relationship is likely due to the option the local driver has to stay at home during inclement weather conditions.

In view of the lack of significant difference between in-state and out-of-state drivers in relation to any behavior category, it can safely be assumed that little, if any, difference exists in the basic driving skills of the two groups.

Number of Vehicles Involved: A disproportionate number of passenger car and truck Icy Roadway accidents involved three or more vehicles. In view of the relationship between Icy Roadway accidents and Failure to Cope With Road Conditions pointed out in Table III-10 it must be assumed that the above deviation resulted primarily from a combination of passenger car and truck driver Failure to Cope With Icy Roadway. In addition, however, truck multiple vehicle accidents were also found to be significantly related to Illegal and Unsafe Actions on the part of the drivers. As was the case with Snowy and Slushy Roadway, the combination of these two factors led to a disproportionate number of three or more vehicle accidents.

While passenger car three or more vehicle involvements were also found to be related to Illegal and Unsafe Actions generally, passenger car accidents resulting from these actions were significantly low on Icy Roadway.

Age of Driver: Passenger car drivers in the 26-35 age range were involved in a significantly high number of Icy Roadway accidents. It will be remembered that this same age range was involved in a higher than expected number of Snowy-Slushy accidents. As was the case in the consideration of 26-35 year old driver involvement frequency on Snowy and Slushy Roadway, no relationship was found between their involvement on Icy Roadway and the various driver behaviors.

Whether some inherent factor is responsible for this deviation or whether the deviation is the result of exposure remains for future research to ascertain. It can be stated, however, that on the basis of data presently available, passenger car drivers between the age of 26-35 were less successful in coping with Snowy, Slushy, or Icy roadway than were drivers in the other age categories.

Estimated Initial Speed: Vehicle involvement in accidents on Icy Roadway occurred significantly often at the lower speed ranges. A disproportionate number of passenger cars were involved at speeds of 11-40 M.P.H.—trucks at speeds of 1-30 M.P.H.

These low speed accidents were found to result from driver Failure to Cope With Road Conditions in a significant number of cases. Illegal and Unsafe Actions, however, also occurred significantly frequently at these lower speeds to justify their inclusion as one of the prime causal factors in these accidents.

It should be remembered in connection with these Icy Roadway accidents that the phrase "Icy Roadway" includes roadway that had icy spots as well as roadway that was predominantly ice covered. Icy spots on an otherwise dry highway add an element of surprise to the Icy Roadway accident picture. Icy spots may actually have a greater accident potential, because of the surprise element, than roadway which is predominantly icy.

That drivers are apparently aware of the hazards of icy roadway is indicated by the reduction in average speeds during these conditions as compared to the average speeds on dry or wet roadway.

Roadway Element: A disproportionately high number of passenger cars were involved in straight down, curved up and curved down accidents on Icy Roadway. Truck Icy Roadway involvements, on the other hand, were found to be significantly high on curved down roadway only.

While Failure to Cope With Road Conditions was a prime factor in both the passenger car and truck deviations, passenger car curved down accidents resulted significantly often as a result of Deficiencies in Routine Driving Skills. Many of the accidents attributable to driver Failure to Cope With Road Conditions would undoubtedly be classed as Deficiencies in Routine Driving Skills were more information relative to these accidents available. Applying brakes suddenly on an icy road, for example, would most likely fall into the Deficiencies in Routine Driving Skills category if the background to the accident and alternative courses of action were known.

Summary: The reclassification of many accidents were additional data available is as applicable here as under the discussion of Snowy and Slushy Roadway conditions. That Icy roadway is extremely hazardous cannot be denied. A realization of the difficulty of the driving task and an awareness on the part of the driver of the proper action to be employed on icy roadway, would materially contribute to a reduction in the hazards of this roadway condition. Remedial consideration, however, must depend on further research.

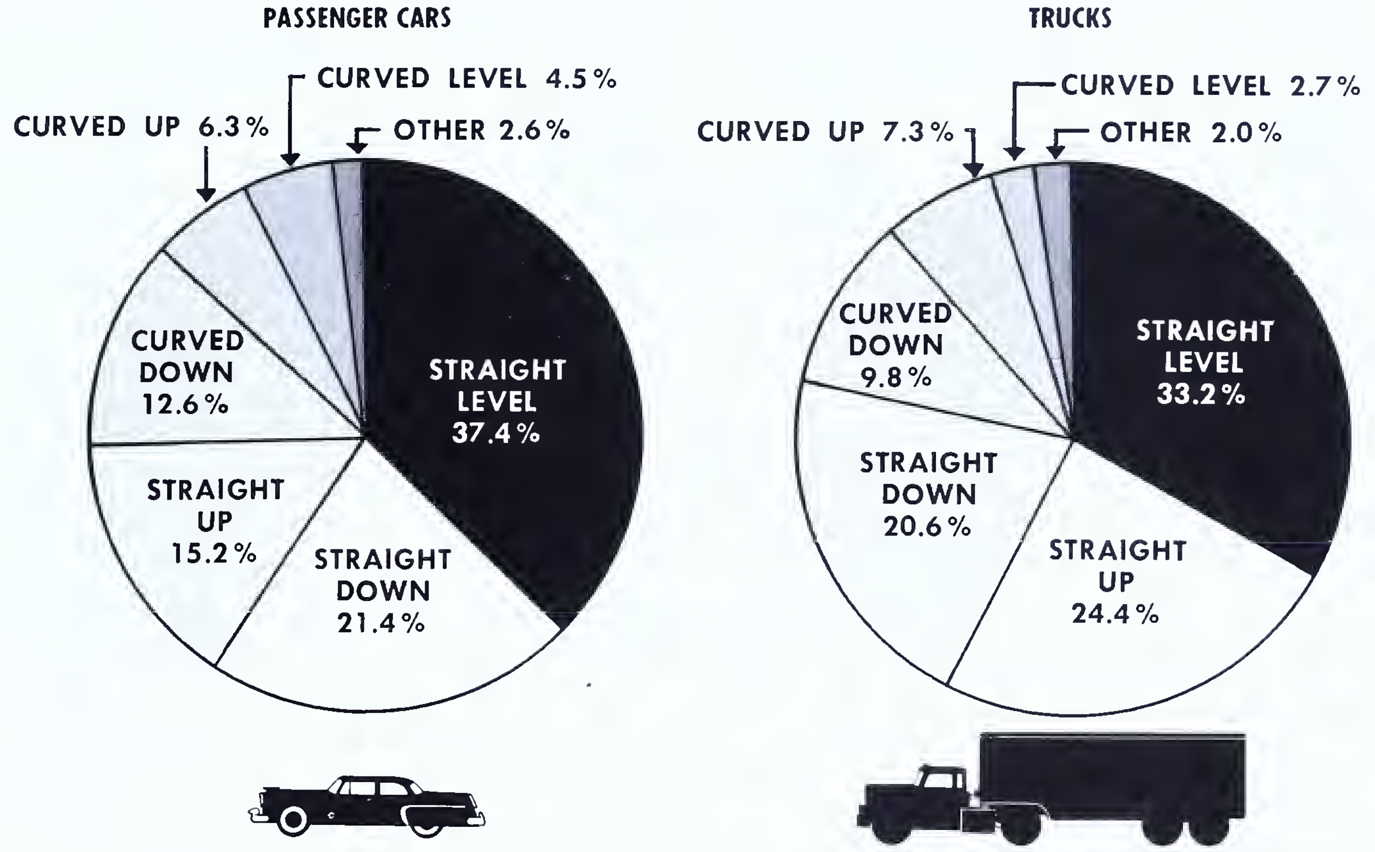
ANALYSIS OF ROADWAY ELEMENT The Roadway Element category has been broken down into six basic sections; Straight-level, Straight-up, Straight-down, Curved-level, Curved-up and Curved-down. It was felt at the start of the research that each of these elements would place different demands on driving skill and ability.

By way of background to the consideration of Roadway Element as a factor in the driving environment, it is important to note that the Turnpike has a maximum curve radius of 6°, maximum grade of 3%, and minimum sight distance of 1000 feet.

FIGURE III-U

Percent of Vehicle Involvement in Accidents by Roadway Element

(1941-1952)



1. ***Vehicle Involvement Frequency:***

Of the various types of roadcourse, Straight-level accounted for the greatest number of vehicle involvements in accidents. This Roadway Element accounted for 37.4% of all passenger car and 33.2% of all truck involvements. Approximately 75% of total vehicle involvement occurred on Straight roadcourse.

2. ***Vehicle Involvement Rate:***

Straight roadway was found to have a slightly higher vehicle involvement rate than Curved roadway. For the year 1952 there were 2.5 vehicles involved in accidents for every million vehicle miles traveled on Straight roadcourse. Curved roadway, on the other hand, had an involvement rate of 2.1 vehicles involved per million vehicle miles traveled. For the purpose of computing these rates, Straight roadway was considered as running from 0° to 30′ curvature. This modification was deemed advisable in order to compensate for the subjective judgment of the reporting officer in assigning a specific roadway element to the place of an accident occurrence. The frequency of occurrence was thus applicable to the determination of vehicle involvement rate per unit of roadway. In the cases where Level roadway is mentioned, the officer's statement was used as the criterion recognizing that there is no absolute level roadway on the Turnpike. A spot check of accident reports revealed a general consistency in the reporting officer's judgment of level roadway.

In view of these rates, it can be assumed that Straight roadway may possibly create a false sense of security in the driver. Curved roadway is generally assumed to require greater driving skill and attention to negotiate than Straight roadway. This very difficulty may serve to keep the driver more alert and attentive to the driving task, resulting in a lower accident involvement rate.

It is recognized that while the overall rates established themselves as they did, there are combinations of heavy grades and sharp curves in specific areas of the Turnpike that have a higher rate than the overall curve and straight rates. This is a point for further specific research, the approach here being to point up the general findings to date.

3. *Roadway Element And Driver Behavior:*

Passenger car accidents on Straight-level roadway were found to be disproportionately high as a result of Failure to Avoid Objects in Road. Higher speeds and relatively light vehicles here again, most likely account for this deviation particularly at night. It is noted in the following table that truck accidents in this category approximate chance frequency as they did under Clear-Cloudy weather and Dry Roadway conditions.

Both passenger car and trucks Asleep and Misperception accidents were significantly high on Straight-up roadway. A significantly high number of vehicles were involved in rear-end collisions on this road element. Relative to other

TABLE III-15

Behavioral Areas of Higher Than Expected Accident Frequency by Roadway Element (1952-1953 Data)

Roadway Element	Passenger Cars	Trucks
Straight Level	Failure to avoid objects in road	
Straight Up	Asleep Misperception	Asleep Misperception
Straight Down	Vehicle failures	
Curved Level	Deficiencies in routine driving skills	
Curved Up		
Curved Down	Failure to cope with road conditions Deficiencies in routine driving skills	Failure to cope with road conditions

Roadway Elements, greater difference exist between passenger car and truck speed on Straight-up section of highway. This is evidenced by the disproportionately high number of truck involvements at speeds of 11-20 mph. Rear-end collisions resulting from driver error in judging the rate of closure of his vehicle may logically be expected to be high on straight-up roadway where trucks travel at slower speed.

Passenger cars were involved in a high number of Vehicle Failures on Straight-down roadway. Brake failure on Straight-down roadway probably contribute substantially to the deviation in this category.

Deficiencies in Routine Driving Skills were found to be high for passenger cars on Curved-level roadway. It is readily apparent that actions such as: tramping on gas on icy highway, cutting wheels too sharply on curve or wet roadway, and trying to slow down while making a curve probably played an important part in Curved-level accidents in spite of the fact that the curves are banked for travel at the higher speed ranges.

Both passenger cars and trucks were involved in a disproportionately high number of Curved-down accidents as a result of Failure to Cope With Road Conditions. Curved-down involvements were disproportionately high during Icy Roadway conditions, as was pointed out previously. These accidents were predominantly medial strip and running off roadway accidents. While Failure to Cope With Road Condition occurred predominantly at "moderate speeds" (21-40 mph passenger car — 11-30 mph trucks), the modification was apparently insufficient to compensate for the difficulty of the task and the drivers ability. This is further evidenced by the significantly high number of Curved-down passenger car accidents resulting from Deficiencies in Routine Driving Skills.

4. *Further Significant Relationships:*

STRAIGHT LEVEL ROADWAY

How Vehicle Was Involved: A disproportionate number of passenger cars were involved in rear-end collision on Straight-level roadway. Table II-3 points up the relationship between rear-end collisions and the behavioral factors of Asleep, Misperception and Illegal and Unsafe Actions.

A significantly high number of trucks were involved in stopped-stopping-parked and fire accidents on Straight-level roadway. Fire accident involvement, as has been previously pointed out, was almost exclusively the result of Vehicle Failures. Stopped-stopping-parked involvements, on the other hand, were found to be significantly related to driver Illegal and Unsafe Actions.

Both of the above passenger car and truck deviations serve to substantiate the assumption that the very ease of negotiating straight road-

TABLE III-16

Significant Relationships Between Straight Level Roadway and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Rear-End	Overturning	Stopped Stopping Parked Fire	Medial Strip Overturning
Estimated Initial Speed	0-10 mph	61-70 mph	—	11-20 mph

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

way may actually increase the accident potential of this roadway element. It should be emphasized that the causal factor here is not inherent in the roadway itself; rather cause must be attributed to the driver behavior on this roadcourse.

Estimated Initial Speed: A significantly high number of passenger cars were involved in accidents at 0-10 mph. It is evident from the speed range involved and the rear-end collision deviation that many of these accidents were rear-end accidents involving parked vehicles and vehicles entering or leaving the roadcourse. A disproportionate number of these lower speed range accidents resulted from Illegal or Unsafe Actions on the part of drivers. A portion of the high involvement rate on Straight roadway is probably attributable to the disproportionate number of stopped, stopping or parked vehicles found on Straight roadway as opposed to Curved roadway.

STRAIGHT UP ROADWAY

How Vehicle Was Involved: A significantly high number of both passenger cars and trucks were involved in rear-end collisions on Straight-up roadway. The behavioral categories covered in the last section (Straight-level roadway) are equally applicable here. One additional point, however, should be mentioned. Of the various roadway elements the greatest speed differential between passenger cars and trucks is found on up grades. Here again the ease of the driving task may enter the picture. Curved-up roadway may serve to keep the driver more alert to the driving task than does Straight-up roadway.

Number of Vehicles Involved: A significantly high number of both passenger car and truck accidents on Straight-up roadway involved two vehicles. This deviation, however, is not surprising in view of the high number of rear-end collisions on this roadway element.

Asleep, Misperception, and Illegal and Unsafe Actions were discovered to be significantly related to two vehicles accidents, as they were to rear-end collisions.

Age of Driver: No significant relationships were discovered between the age of passenger car drivers and Straight-up vehicle involvement.

A disproportionately high number of truck drivers 26-35 years of age were involved in Straight-up accidents. This deviation is complicated by the fact that no relationships were found between the age of truck drivers and the various behavioral factors. While it is important to state that this deviation was discovered, little value can be gained from drawing hypotheses on the

TABLE III-17

Significant Relationships Between Straight Up Roadway and Various Accident Factors

(1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	Rear End	Overturning	Rear End	Overturning
Number of Vehicles	2 Vehicles	Single Vehicle 2 or More Vehicles	2 Vehicles	Single Vehicle 3 or More Vehicles
Age of Driver	—	—	26-35 Years	—
Estimated Initial Speed	—	1-10 M.P.H.	11-20 M.P.H.	41-50 M.P.H.

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

basis of the data presently available.

Estimated Initial Speeds: As might be expected from the nature of rear-end collisions, a significantly high number of truck Straight-up accident involvements occurred at speeds of 11-20 m.p.h. Conversely, significantly few trucks were involved in Straight-up accidents at speeds of 41-50 m.p.h. It is evident from this speed deviation that trucks were most often the struck rather than the striking vehicle. The role of Misperception and Asleep, therefore, must be attributed to the passenger car drivers involved in these accidents.

TABLE III-18

Significant Relationships Between Straight Down Roadway and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
How Vehicle Was Involved	—	—	Overturning	Rear End
Number of Vehicles Involved	3 or More	2 Vehicles	Single Vehicle 3 or More	2 Vehicles
Estimated Initial Speed	—	51-60 m.p.h.	—	11-20 m.p.h.

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

STRAIGHT DOWN ROADWAY

No relationships were discovered between passenger car involvements on Straight-down roadway and type of involvement. A disproportionately high number of trucks, however, were involved in overturning accidents on Straight-down roadway element. Although no relationships appeared between truck Straight-down accidents generally and the various driver behaviors, Vehicle Failures played an important part in overturning accidents generally.

Both passenger car and truck three or more vehicle involvements were significantly high on Straight-down roadway. Truck single vehicle accidents were also higher than expected on Straight-down roadway, strengthening the hypothesis that Vehicle Failures contributed disproportionately to truck Straight-down accidents. The frequency of 3 or more vehicle accidents, as has been previously mentioned, is indicative of illegal or unsafe actions on the part of passenger car and truck drivers.

Significantly few passenger cars were involved in accidents on Straight-down roadway at speeds of 51-60 m.p.h. Conversely truck involvement on Straight-down roadway was significantly infrequent in the lower speed range—11-20 m.p.h. While the truck deviation, in this case, can likely be attributed to exposure, the passenger car deviation is somewhat surprising in view of the radar speed check findings. No logical explanation of this deviation is apparent on the basis of present data.

Straight Roadway Summary: Straight roadway is generally accepted as presenting the easiest driving task to the driver from the standpoint of roadway elements. Surprisingly enough, however, the vehicle involvement rate on this type of roadcourse is higher than the curved roadway rate.

The very ease of the driving task is most likely the predominant factor accounting for this unexpected rate. This "ease" may delude the driver into grossly underestimating the need for constant attention to the driving task required

TABLE III-19

Significant Relationships Between Curved Roadway and Various Accident Factors (1941-1952)

	Passenger Cars		Trucks	
Accident Factors	*High	Low	High	Low
Curved Level				
Number of Vehicles Involved	Single Vehicle	3 or More	—	—
Estimated Initial Speed	51-70 m.p.h.	0-m.p.h.	—	—
Curved Up				
How Vehicle Was Involved	Medial Strip	—	Medial Strip	—
Estimated Initial Speed	61-70 m.p.h.	—	11-20 m.p.h.	—
Curved Down				
How Vehicle Was Involved	Medial Strip Collision With Object Other than Vehicle Overturning Running Off Roadway	Rear-End	Medial Strip Overturning Running Off Roadway	Rear-End

**High-Low: Areas that are significantly higher or lower than would be expected on the basis of chance alone.*

under all environmental conditions.

The significantly high number of accidents which resulted from Asleep and Misperception on straight roadway serve to substantiate this conclusion.

CURVED ROADWAY

Curved-Level Roadway: While no significant relationships were discovered between truck Curved-level accident involvement and the various accident factors, passenger car Curved-level accidents were disproportionately often single vehicle accidents involving vehicles traveling at 51-70 m.p.h.

Table II-9, points up the relationship between passenger car accidents at speeds of 51-70 m.p.h. and Failure to Avoid Objects in Road, Asleep, and Attending Other Tasks. In addition passenger car Curved-level accidents were found to result significantly often from Deficiency in Routine Driving Skills. (Table III-15)

The driver behaviors listed above are potential accident behaviors on any roadway element at any speed. The combination of these behaviors on a curved roadcourse at the relatively higher speed, however, indisputably increases the accident potential. To place speed in its proper perspective, however, it is interesting to note that only one of the above classes of accidents would have been substantially lowered by a reduction in speed. Driver failure to avoid objects in the road is undoubtedly related to higher speeds. On the other hand a driver who falls asleep, is inattentive, or is deficient in routine driving skills is a hazard at any speed. Asleep accidents on curved level road at 51-70 m.p.h. are more likely a function of the driver falling asleep than a function of the 51-70 m.p.h. speed.

Curved-Up Roadway: A disproportionate number of Curved-up roadway accidents were medial strip accidents. These accidents involved a significantly high number of passenger cars at speeds of 61-70 m.p.h. and trucks at speeds of 11-20 m.p.h.

Passenger car Curved-up accident involvements appear to be similar, relative to driver behavior, to passenger car Curved-level involvements. An additional factor, however, is indicated by the type of accidents. Passenger car medial strip accidents occurred disproportionately often as a result of Failure to Cope With Road Conditions.

Truck Curved-up accidents, as has been mentioned, were disproportionately often in the lower speed range. The low rate of speed of trucks involved in Curved-up accidents is indicative of a relationship between these truck accidents and Failure to Cope With Road Conditions. Such a relationship is found in Table II-9 of Chapter II.

Curved-Down Roadway: A striking similarity was found between passenger car and truck types of involvement on Curved-down roadway. A significantly high number of both passenger cars and trucks were involved in medial strip, running off roadway, and overturning accidents on Curved-down roadway. In addition passenger car collisions with objects other than vehicles were higher than expected on this roadway element.

Little similarity, however, was found in the driver and vehicular behaviors which precipitated the accidents. Truck overturning accidents, for example, were found to be significantly related to Vehicle Failures. Passenger car overturning accidents were also significantly related to Vehicle Failure but Deficiencies in Routine Driving Skills also played an important part in passenger car overturning accidents.

Running off roadway accidents are another example of practically identical passenger car and truck accidents precipitated significantly often by different factors. Passenger car accidents of this type were significantly related to Failure to Cope With Road Conditions, and Deficiencies in Routine Driving Skills. Truck running off roadway accidents, on the other hand occurred disproportionately often as a result of Vehicle Failures. (Table II-3)

Passenger car accidents involving collision with objects other than vehicles resulted predominantly from Failure to Avoid Objects in Road. A relationship of this nature is partially a function of the terminology employed in setting up the data.

No significant relationships were discovered between any of the remaining accident factors and the frequency of passenger car and truck involvements on Curved-down roadway.

Curved Roadway Summary: Curved roadway undoubtedly requires a greater degree of driver skill and attention to negotiate than does straight roadway. Drivers generally appear to meet these demands more successfully than they do the lighter demands of straight roadcourse. The Curved Roadway vehicle involvement rate is slightly lower than the Straight Roadway rate.

The increased demands of curved roadway may actually serve to keep the driver more attentive to the driving task—resulting in a relatively lower vehicle involvement rate.

GENERAL CONCLUSIONS The preceding sections of the present chapter have indicated the various ways in which environmental variables interact with driver behaviors. While the environmental analysis points out the effects of environment on the driver's visibility, the vehicle's traction, the tasks on a changing road course, it was soon discovered that the environment has an additional and not so apparent effect on the driving task. Environmental conditions affect certain general living habits which weigh heavily in the formation of traffic density and traffic pattern under different conditions of place and time.

It was found, for example, that traffic volume is subject to such factors as driver preference for so-called "ideal" environmental conditions and weekend trip patterns. Traffic patterns are related to not only traffic volume but also to specific places such as tunnel portals and approaches, gas station areas and interchange areas where vehicles entering and leaving the main line of traffic result in a more dynamic traffic pattern than the more or less static main line normal section of roadway. In addition, unfavorable roadway and weather conditions often result in bunching of traffic not found under better environmental conditions. Time of day, in addition to its role as a visibility factor, is also reflected in those night time accidents resulting from falling asleep. While falling asleep accidents occur under all light conditions they occur significantly often at night.

The fact that the very great majority of drivers safely traverse the highway under all weather and road conditions would seem to indicate that in general they adequately adapt their driving to the existing conditions. The relationships which have been discovered between environmental conditions and accident-behaviors indicate that drivers who failed to adapt their driving procedures to existing conditions were the ones who experienced accidents. Thus, inexperienced drivers who fail to adapt their speed to downhill curve conditions may be expected to run off the road with periodic regularity; servicemen who attempt to squeeze a two-week furlough into a three-day pass may be expected to lose sight of their driving limitations on the highway. These things happen. They are actual events that are causing the present accidents on the Turnpike, not mere speculation of cause.

The entire gamut of driver behaviors covered in this report are basically what cause accidents. These behaviors are modified by the environmental conditions. The various environmental conditions directly affect the difficulty of the driving task. However, drivers are not free of malpractice under the easier driving conditions. Some behaviors are, in fact, more hazardous under ideal conditions. Regardless of the environmental conditions and the driving task, it must be concluded that basic cause and responsibility lies with the driver. It remains for future research to demonstrate various means of influencing driver behavior so that operators adapt their procedures and techniques to the requirements imposed by the driving environment.

APPENDIX A

HIGHWAY SAFETY—A SELECTIVE REVIEW OF THE LITERATURE

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INTRODUCTION

PURPOSE OF THE REVIEW Scientific progress in any area of endeavor is always heavily dependent upon preceding investigations. It is only by summarizing and codifying existing data that generalizations may be proposed which will stimulate further investigations, leading, in turn, to tangible progress.

In the field of highway safety, several excellent comprehensive reviews of research are available (see bibliographic references: 40, 202, 319).* Unfortunately, two of these were written fourteen years ago and the other 24 years ago. A substantial number of research studies have been conducted in the past decade which provide information on points left unanswered by these previous reviews. A fourth available review article which presents recent data concerning industrial, highway, and aircraft accident data, and which is a classic in the field, does not provide information on several points of interest to the Joint Highway Research Group (331). It would seem that a need exists for a review to cover the more modern research discoveries and to integrate these data with the results of the earlier investigations. It is to be hoped that such a review will provide information for those concerned with supplying recommendations for highway accident reduction, and that it will highlight areas requiring still further analyses.

It has been shown repeatedly (314) that a small number of individuals account for a large proportion of accidents simply because some persons incur several. When this tendency was discovered it was immediately seized upon as being evidence for a general characteristic of "accident proneness" in certain persons. A horde of investigations was undertaken to discover tests which would predict accident proneness. Many persons, scorning the use of objective techniques, relied upon their personal experiences in listing the characteristics of accident prone persons. Such individuals are still active and their impressions may be read in almost any newspaper.

Frequent tabulations of accident occurrences were not long in print before statisticians cast considerable doubt on the validity of the assumption that the accident prone person actually existed. It was demonstrated that if chance factors alone were operating, certain persons would still have several accidents, irrespective of any personal characteristics. The obtained distributions of accident occurrence closely approximated chance distributions of various mathematical models. Unfortunately, no sensitive test was available to determine whether the two distributions were sufficiently alike to indicate that accidents could be attributed to chance.

Moreover, for the persons included in the lists purporting to demonstrate "accident proneness," few attempts were made to equalize exposure to driving hazards such as weather conditions, type of driving, etc., and, again, since no sensitivity test of goodness of fit was available, it could not be determined whether discrepancies between the observed accident frequencies and the mathematical models were real differences.*

Meanwhile, studies attempting to isolate characteristics of the accident prone person were bearing fruit. Although none of the studies can be considered as conclusively demonstrating the existence of a general trait of "accident proneness" they do, taken in their entirety, indicate that deficiencies in several areas may render an individual more suspectible to incurring an accident.

METHODOLOGICAL CONSIDERATIONS In a large proportion of the studies which have been conducted to determine the relations between certain human characteristics and highway accidents

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**Dr. Forbes has prepared an outline of the field of highway safety research for the National Research Council Committee on Highway Safety Research. This manuscript was not available at the time the present review was in preparation.*

**For an excellent technical discussion of the statistical issues involved in the accident proneness problem see, Fitzpatrick, R., "The Prediction of Accident Susceptibility in a Group of Fighter Pilots." Ph.D. Dissertation, Univ. of Pittsburgh, 1953.*

there are a number of limiting factors that preclude the generality of the findings. A critical evaluation of many of the studies reporting on highway accidents is often difficult or even impossible to make because they are so poorly reported. Some studies cite results which appear to have real merit; for others the results appear questionable. Many investigators in this area have overlooked the necessity, or at least the desirability, of instituting adequate controls. Others, who may have included control groups in their research studies, have failed to utilize accepted and readily available statistical tests of significance. A third major error committed by many investigators is the failure to select adequate representative samples of automobile drivers. Therefore, conflicting data in the various studies bring into question the validity of certain of the findings.

There are only a few research articles in the area of highway safety which have been so designed and reported that they can be repeated, and published findings thereby checked. Future studies in this area need to give greater consideration to the simple research criterion of replication if systematic knowledge of the human causal factors of accidents is to be extended. Many of the available articles listed in the present bibliography are based on clinical reports and speculation. Although these may have certain values of themselves, they should lead eventually to quantitative investigations. Until the insights of these authors are buttressed by factual data, it would be well to view them as hypotheses to be proved rather than demonstrated facts. For the most part, such reports are given very cursory, if any, consideration in the present review.

DESCRIPTION OF CONTENTS Investigations in the area of highway safety have been of two general types; those concerned with discovering the most efficient means of moving traffic with a minimum of hazard, which we may term engineering studies; and those of a psychological nature which have been concerned with discovering characteristics of the driver which directly contribute to accident occurrence. The majority of the present report reviews findings in the latter area. For review purposes, they have been classified under three general areas: those dealing with physical attributes of the driver as causative factors, those dealing with his knowledge of driving skills, and those concerned with his personality, motivations, and attitudes. This is admittedly an arbitrary classification, for the constitutional, intellectual, and temperament aspects of an individual's behavior are interacting.

In selecting articles to be included in the review, no attempt has been made to be exhaustive. The review is concerned primarily with research on automobile driver characteristics, and with research which has been conducted in the United States. Some exception was made to this policy when, during the literature search, several excellent British articles were reviewed.

I. CONSTITUTIONAL FACTORS IN RELATION TO HIGHWAY SAFETY

INTRODUCTION As in the study of aircraft accidents, one of the primary considerations investigated in studying highway accidents has been the role of the driver's physical capacities as causal factors. For example, during World War I it was believed that tests of vision, reaction time and coordination were necessary and sufficient for the selection of safe pilots. World War I pilot selection tests consisted almost exclusively of these measures. Research soon established that much more was involved. The present pilot selection tests reflect increased sophistication with respect to physiological factors, but many personnel engaged in highway safety research are still at a World War I level in their beliefs.

VISION It is clear that certain minimum standards of visual acuity are quite necessary for the successful operation of a motor vehicle. Above this minimum, however, it remains to be demonstrated that visual factors are *important* in accident causation. Many people believe that they are. Among the visual defects frequently mentioned as contributing to accidents are: visual acuity of both eyes and inequality of acuity between eyes, poor perception of depth and distance, narrowed field of vision (tunnel vision), scotomata, uncompensated blind spots, phorias, astigmatism, retinal abnormalities, myopia, defective night vision, color blindness, and susceptibility to glare.

Though these factors may "logically" be expected to reduce driver proficiency, the number of studies which have been conducted and which demonstrate that a relationship exists is not large. Moreover, a random selection of non-accident drivers has rarely been tested so it is difficult to say with assurance that the visual factors above are actually important causal factors.

Thorndike (331) has pointed out an additional limitation insofar as the paucity of clear-cut evidence of the importance of visual factors is concerned, though it applies equally to all studies of differences between accident-repeater and accident-free drivers. "Accidents can be so varied in their circumstances and causes that a particular factor, such as defective night vision, should be expected to be significant in only a small minority of cases. Its influence, if any, is thus masked by the great number of accidents which had quite a different causal background." (331, p. 58.) He suggests a research design which partially overcomes this difficulty. The investigator should select a group of accidents which are similar in certain characteristics and which are logically the ones in which the expected factor should have operated. Thus, if the factor studied is depth perception, one might limit the accident group to those involved in rear-end collisions. If relationships exist between visual factors and accidents, they may then be expected to show up more clearly.

Just such a research design was utilized by Cobb (68). He administered a large battery of driver tests to 3,663 drivers licensed in Connecticut. As Johnson (168) points out, "This state records the general accidents, violations, convictions, etc., with unusual care, and perhaps more nearly completely than any other state does." Seventy-two tests were administered to the drivers. The operators were then classified according to their scores in a particular test trait and for every sub-group of drivers possessing this particular trait, the proportion of their accidents which belonged to the type to which they were "supposed" to be susceptible was determined. The results of this analysis follows:

> Sensitivity to glare was *not* found to be significantly associated with a preponderance of night accidents over other accidents;
>
> defects of color vision were *not* found to be significantly associated with a preponderance of accidents at signal protected crossings over other accidents;
>
> tests of distance judgments were *not* found to be significantly associated with a preponderance of rear-end collision accidents over other accidents;
>
> inequality of actuity in the two eyes was *not* found to be significantly associated with a preponderance or rear-end collision accidents over other accidents;
>
> simple reaction time to auditory stimuli was *not* found to be significantly associated with rear-end collision accidents or passing accidents over other types;
>
> scores on "vigilance tests" were *not* found to be significantly associated with a tendency toward rear-end collisions or passing collisions over other types of accidents;
>
> but the variability of reaction time for particular drivers was found to be very

> slightly associated with rear-end collisions or passing collisions. (As is pointed out by Johnson (168) the relationship is so slight that the test would properly classify only twenty-eight accidents out of 1,487 that would have been improperly classified by chance.)

Lauer (113, 178) also investigated the relationship between vision and driving performance, using apparatus for presenting successive stimuli in near and far positions. In studying binocular coordination in 500 subjects, he determined that there was no significant difference between accident and non-accident drivers.

Ellis and Hare (112, 113) studied muscular imbalance, visual acuity, and the effect of artificially induced defects in 33 accident cases and 150 controls and found no significant differences.

Burtt (54) found no results having predictive value so far as accident and non-accident drivers are concerned when he presented various visual stimuli and measured the speed of reaction time.

Additional evidence of the unimportance of visual factors in discriminating between accident and non-accident groups of drivers follows.

Ghiselli, Brown and Minium (139) studied 153 streetcar motormen. They failed to find any difference between accident score for those who did well and those who did poorly on tests of visual acuity, fields of vision, and glare recovery. Lauer (178) studied 24 accident drivers and 24 non-accident drivers for ability to name colors and to discriminate letters at both near and far points. He failed to find any significant differences between the two groups. Burtt and Forbes (56) studied perception of rate of movement. This test utilizes an object moving at a uniform speed which disappears behind a screen. The subject is required to judge when it will pass behind an indicated spot on the screen. They found no tendency for accident-free cases to be superior to those who had been involved in accidents. DeSilva, Claflin and Simon (99) studied the performance of the best and worst 10% of a group of 111 drivers who had been selected on the basis of accident record over the preceding nine years of employment in a single large company. Visual measures utilized tested glare susceptibility, peripheral vision, depth perception and visual acuity. No significant differences were found between the two groups. Brody (42) examined 26 accident repeater drivers and 26 non-accident drivers for visual acuity, color blindness, ocular muscle balance, dark adaptation, depth perception, and side vision. The only measure which showed a significant difference was side vision. It will be noted that although side vision was found to be important in Brody's study, it was not found to be significant in the study by De Silva cited above, nor in the study by Ghiselli also cited above.

A study carried out by the New York University Center for Safety Education and sponsored by the Eno Foundation (114) also presented evidence of the unimportance of measures of side vision insofar as determining accident liability is concerned. This study measured groups of 100 accident-repeaters and 100 non-accident drivers who had been matched on certain background factors; sex, age, driving experience, and type of vehicle driven. It is interesting to note, however, that contrary to the findings cited above, these investigators found that the non-accident group scored significantly better on the following visual measures: visual acuity, depth perception, and vertical and lateral ocular muscle balance. They found no significant differences between the groups in size of lateral visual field (as was previously mentioned) or in rate of dark adaptation.

It might be argued, however, that there are visual defects which are not screened out by present day examining techniques. For example, there is the principle of narrowing field of vision with increased driving speed; as speed increases the point of concentration moves farther away, the detail of foreground vision begins to fade, and side-vision diminishes. Thurstone and Hamilton (150) state, however, that speeds of between 45 and 50 mph still have relatively little effect upon field of vision insofar as the average good driver is concerned. It is evident that this phenomenon would be less important with respect to expressway driving than it would be in congested urban areas. In expressway driving there is little danger of a driver being approached by a vehicle coming from the side, as would occur if intersections were built into the highway.

In summary, it may be stated that although the evidence for the importance of visual factors in accident causation is extremely modest, there is also some evidence that these conditions may have some slight influence in certain accidents. The lack of any clear cut relationships may be due to several factors: the unreliability or, at best, limited reliability of both visual tests and accident records, and the probability that only a small fraction of highway accidents have visual limitations entered as a contributing cause. An additional consideration is the possibility that an individual may compensate for his known defects and, by being especially careful, may avoid becoming a member of the accident-driver group. For example, people who are aware of their defective night vision may avoid driving at night.

It must be remembered that many of the articles stressing the importance of vision were written at a time when relatively few of the states required visual checks in their driving examinations. Seeming discrepancies between such points of view and the results of controlled studies in this area may possibly be due to the fact that those persons stressing the importance of defective vision as causal factors in accidents may have based their opinions on situations existing in the early 1930's. With the screening out of drivers with defective vision by improved driver licensing procedures which have been adopted by many states, it is possible that the role of visual factors in causing accidents is greatly reduced for the present-day driving population.

PSYCHOMOTOR ABILITIES A number of studies have been conducted which have been concerned with determining the relation between accident occurrence and such variables as the driver's simple or complex reaction time, strength of grip, speed of tapping, gross muscular movements, etc. It is difficult to formulate any clear conclusions from these studies since the criteria of driving success varied, various investigators selected their samples according to different criteria, the reliabilities of the measures employed were rarely determined, and in most cases statistical tests of significance were not conducted.

In general, available evidence indicates that accident-drivers do not differ from accident-free drivers in simple reaction time. Differences may be expected on more complex choice reaction-time tasks, especially when physical distractions or factors of emotional stress are introduced into the testing situation.

Johnson and Evans (171) investigated the relationship between various psychomotor tests and ratings of driving ability. Each subject was rated by one examiner on the basis of his driving performance over a standard course on regular city streets. The single large predictor was the test of choice reaction time. Speed of foot movement and foot reaction time had lower, but significant, predictive value. No attempt was made to relate these ratings of driver ability to other criteria such as number of accidents sustained. Therefore it is difficult to accept the findings regarding certain psychomotor tests as being indicative of any accident potentialities on the part of the drivers involved.

Brody (42) tested simple and complex reaction time of a group of 26 drivers who had been involved in at least three reported accidents in the previous five year period and 26 volunteers who were accident-free. All persons had driven at least fifty thousand miles. He found no significant differences between the groups on tests of simple or complex reaction times. He feels that speed of reaction time, especially in the application of brakes, has been overemphasized as a factor which predisposes drivers toward accidents. In those cases where significant differences have been found, for example, the differences in terms of distance traveled are still so small as to be negligible.

Greenshields (147) tested simple reaction time of a group of 87 accident drivers and 145 accident-free drivers. He found no difference in reaction time between these two groups. On the other hand, Forbes (131) tested 138 accident-repeater drivers and 52 volunteers who were assumed to have average accident records. Tests administered were those of simple brake reaction time, vigilance brake reaction time, steering, and braking-steering balance. On *all* tests the repeater group obtained significantly poorer scores. Using the same series of tests (The Harvard Traffic Bureau Series) Bransford (41) obtained results for 1,339 persons. Of all the measures obtained, the test of brake reaction time was the *only* measure which was significantly related with arrest and accident criteria. Its importance was reduced when correction was made for age of subjects. In a third investigation using the Harvard Traffic Bureau Battery (98), tests were administered to 649 accident drivers and 186 volunteers in five cities. In at least two out of three of the cities, deficiencies were found on the following tests to be statistically reliable for the accident-repeater group: simple reaction time, simple steering, vigilance steering, vigilance differential, and vigilance ratio.

It will be noted that the last three studies employed the same test battery. The tests were administered by persons who were competent in their fields. The results differ markedly for each study. This may be due in part to the fact that the selection of criterion groups was largely based on the availability of subjects. Thus, differences are in many cases a function of the particular group tested. Consequently, it is difficult to determine the generality of the findings reported.

Of all studies reviewed, the one which involved the most extensive testing was conducted by Cobb (68). In this project some 72 different predictor variables were analyzed. In addition to certain physical, physiological and biographical facts about each individual, the test battery included the Harvard Traffic Bureau Series and the Iowa Series. Tests were administered to more than 3,000 drivers in the state of Connecticut. The sample included drivers who had experienced recent accidents and a group of volunteers. The sample is not representative of the general run of Connecticut drivers. Scores on the various tests used were correlated with the number of accidents on record for the individual in the Connecticut State files divided by the number of years the driver had been licensed in Connecticut. Correlations between the psychomotor tests and the criterion were uniformly small. The relations were, however, significant in many cases. Among the measures for which significant relationships were found were strength of grip, speed of tapping, sensory braking reaction time, steering and vigilance steering. An estimate of the magnitude of these relationships may be arrived at by considering their contribution when they are combined with other tests to serve as a single predictor of accident rate. A combination battery of 22 tests was found to have a multiple correlation of .35 with the accident rate criterion. An analysis of nine pencil and paper measures revealed a similar multiple correlation coefficient (.305), suggesting that the apparatus tests of psychomotor functions made relatively little contribution in prediction.

In the Cobb study, an investigation was also made of the relationship between various psychomotor measures and accident type. No significant relations were found. It was discovered that variability of reaction time was slightly related to a preponderence of rear-end collisions; however, in view of the total number of such analyses made, the single analysis approaching significance may be explained as a chance outcome (1 out of 11). An additional point which must be considered in evaluating the relationships found is concerned with the failure of the examiners to calibrate their apparatus instruments regularly. Due to this oversight, it was discovered, after all of the data was in, that several pieces of equipment had developed defects. It was then too late to correct scores for such biases, yet such data were included in regular analysis. Also, 98 cases for which accidents were recorded were included in the accident-free group of the test sample. The final correlation coefficients reported were not corrected for this error.

In summary, it may be stated that the results of investigations of the relation between psychomotor abilities and accident rate are highly contradictory and controversial. It would seem that more work is necessary in this area, and that considerably more attention should be given to the careful selection of both accident and non-accident samples and that more care should be taken in testing these samples.

PHYSIOLOGICAL CONDITIONS

1. *Autonomic system reactivity*

Inasmuch as the functioning of various of the endocrine glands is accepted by many as being indicative of emotionality, some investigators have attempted to relate measures of autonomic reactivity to accident indices. The general point of view seems to be that emotionality, as surmised from high blood pressure, rapid pulse, and large galvanic response, is related to accident frequency. And, indeed, a relationship has been found. It is, however, of approximately the same magnitude as the relationships which have been found to exist between certain measures of reaction time and accident rate; in other words, the relationship is extremely small. Significant positive results with respect to blood pressure have been reported by Brody (42), Cobb (68), Kraft and Forbes (173, 174), and Slocombe and Brakeman (313).

The validity of blood pressure measures in distinguishing accident-repeaters has not been established. Slocombe and Bingham (312) found high blood pressure to be related to accident frequency. The Eno Foundation (114) reported no significant differences in either direction.

The importance of these findings is not immediately clear. As Thorndike (331) has observed, these various physiological measures reflect a large number of interacting factors such as age and health. There is some question, therefore, whether they are real indicators of emotionality. Until extraneous factors are controlled there can be little confidence placed in such findings. It is possible, of course, to accept them as tentative relationships.

2. *Alcohol*

The question of the relation between amount of alcohol consumed and highway safety is a complex one, and one which has received considerable attention. The present review will not presume to summarize all the studies which have been done in this area. The studies themselves defy any simple codification. They range from emotional articles unsupported by evidence to articles dealing with research which has been aimed at solving particular problems, e.g., does alcohol affect reaction time, does alcohol affect precision of movements, how much alcohol is necessary before movement is impaired to any given extent, what per cent of drivers involved in accidents had imbibed a sufficient quantity of alcohol to impair their responses, how does the per cent of drunken drivers involved in accidents compare to the per cent of drunken drivers not involved in accidents, etc.

For some of these questions, answers may be given with confidence. There is little doubt that alcohol in sufficient quantity does affect both the speed of reaction and the accuracy of motor responses. There is also evidence available in the literature that it impairs "judgment" and "reasoning" abilities. For others of the questions the evidence is equivocal. Some of the difficulties involved in responding to these questions are listed by Berry (33). He points out that statistical information regarding drunken driving comes from two general sources:

a. police and driver reports filed with official state and government units given in (1) routine monthly and annual summaries of general frequency of alcohol influence and (2) special studies giving circumstances of accidents.

b. studies involving chemical tests of body fluids or breath of persons injured or killed in accidents.

Data coming from these sources often yield conflicting results. Reasons for variations in the reported figures are the following:

a. the information on the report reflects the opinions of the drivers and the officers who make out the reports,

b. in some states the greater number of accidents are investigated by police officers who are not trained in accident investigation,

c. the reporting of circumstances is much more complete in some states than in others,

d. figures reported by different cities and states are based on different definitions. Descriptive terms used vary from "intoxicated" to "under the influence" to "had been drinking."

He concludes that a tremendous variation is possible in stating the part which alcohol plays in traffic accidents. Special studies are too few in number to base general statements upon them. No one can say exactly how many motor vehicle accidents are due to alcohol.

One study which was carefully conducted to answer several of the above questions is that of Holcomb (156). He studied the drinking of drivers involved in personal injury accidents compared to the drinking of drivers in the general population, to define objectively the part alcohol plays in the accident problem. Also considered was the concentration of alcohol in the human system necessary to become a factor in accidents. Two hundred seventy drivers involved in personal injury accidents who took persons injured to the hospital, or drivers who themselves were injured, were tested by urinalysis for alcohol. One thousand, seven hundred fifty drivers chosen at random from approximately the same geographical area (Evanston, Illinois) were administered breath tests for alcohol. Comparisons were made on the basis of hour of day, day of week, and blood alcohol content.

It was found that the largest number of drivers who had been drinking occurs in the early evening hours and on week ends but the drinking drivers, proportionate to non-drinking drivers, are highest in number during the early morning hours and over the week end. The percentage of drinking drivers in the general population varies proportionately to the percentage of drinking drivers in the personal injury group but is considerably lower at all times. As blood alcohol content increases, the number of drivers appearing in the personal injury accident group increases out of all proportion to that in the general driving population.

Holcomb found that 47% of the accident group had some alcohol concentration in their blood stream compared with only 12% of the control group. Thorndike (331) reworked Holcomb's data to show the ratio of accident to comparison cases at each level of alcohol concentration. These data are presented below, expressed as accident cases per 100 cases in the comparison group.

Thorndike points out that these figures are not completely reliable due to the small number of cases in the control group at the higher levels of alcohol concentration. There is a definite trend, however, as he points out. The table cannot be used to establish a lower alcohol concentration level at which no effects upon accident frequency can be found. Any alcohol at all in the blood seems to have some effect upon accident rate.

The National Safety Council Committee on Tests for Intoxication (251) lists .15% alcohol concentration in the blood as a critical upper limit. They, too, have decided that no minimum level could be set at which it could be asserted that there were no harmful effects upon driver performance.

3. *Fatigue:*

For some reason, fatigue as a factor in automobile accident causation has received relatively little attention. This may, perhaps, be

TABLE I

Relative Frequency of Automobile Accident Cases for Different Alcohol Concentrations

Amount Consumed*	% Alcohol in Blood	No. of Accidents per 100 Control Cases
0	None	9
1-2 oz.	Less than .04	45
2-4 oz.	.04 to .07	21
4-6 oz.	.08 to .11	53
6-7 oz.	.12 to .14	146
8 or more oz.	.15 and over	577

due to public acceptance of the idea that as a person becomes progressively more tired his driving competence will deteriorate. Or the lack of controlled experimentation may be due to the difficulty of defining and/or measuring "fatigue".

The term fatigue actually has at least three meanings. (1) It may be defined as the feeling or tiredness (subjective fatigue) which may arise as the result of prolonged physical exertion or which may also result from periods of inactivity or boredom. It can be measured simply by asking a person how he feels. (2) There is the concept of fatigue as determined from bodily changes (physiological fatigue). According to this concept, fatigue is a result of formation of waste materials in the system as a result of muscular activity and can be measured by appropriate physiological tests. (3) The third concept of fatigue is more vague and yet more consistently measurable. It is that a person may be considered fatigued if his performance shows a progressive deterioration (objective fatigue). Thus, the measure is directly of performance and decrements are attributed to "fatigue". Whether a person prefers to think of fatigue as being subjectively or physiologically determined is unimportant.

Since no satisfactory means of objectively measuring driver competence exists, it is necessary, in measuring the effects of fatigue, to assess decrements in performance of tasks which are *assumed* to be related to the driving task or to measure physiological changes which are *assumed* to influence driving skill. If physiological changes or decreased levels of performance are found it is presumed that evidence exists that driver performance will deteriorate simultaneously.

Or, if the investigator uses subjective reports of drivers as indicators of fatigue he must *assume* that fatigue influences driver competence in some way. The possibility must be kept in mind that a driver may "feel tired" (bored?) and yet still be able to manipulate his vehicle successfully through heavy traffic.

This discussion should not be interpreted as a denial that excessively prolonged driving will result in seriously lowered driver competence. The importnat issue is not whether a driver will eventually fall asleep at the wheel, but how long he can drive before dangerous decrements in performance may be expected to result. Since the country will soon be covered with a network of limited access freeways a driver could conceivably travel almost indefinitely, pausing only briefly to refuel. If fatigue effects can be found to be important in reducing driver efficiency then legislation could be enacted to require that periodic rest stops be made.

A study conducted by the United States Public Health Service (270) may illustrate several of the points raised in the above discussion.

**To make the information in Table I more meaningful, the present writer has added a column to indicate the amount of alcohol which must be consumed in order to achieve a given concentration of alcohol in the blood. The figures are based upon consumption of "100 proof" whiskey by a 160 lb. man. They are only approximate since absorption of alcohol into the blood stream will vary with the amount and type of food in the stomach.*

A team of biochemists, medical doctors, physicists, physiologists, and psychologists studied 889 trucks drivers who had driven from 0 to 16 hours since they last slept. A large number of tests was used. (But no direct measure of driving proficiency was included in the battery.) Psychophysical measures which showed consistent changes with hours of driving were: speed of tapping, reaction-coordination time, simple reaction time, steadiness, body sway, vigilance and flicker.

It is difficult to translate these results into assumptions about their effect upon driving skill. For example, strength of grip was stronger with increased driving time and a person might surmise that this might mean better control. (?) Also, it is known that the amount of caffeine in several cups of coffee will result in decreased performance on steadiness or body sway tests, yet coffee is frequently recommended as a way for drivers to remain alert. Is one to assume that unsteadiness from fatigue is detrimental to driving efficiency but that unsteadiness from drinking coffee has no effect on driver performance?

The same study recorded the drivers' subjective feelings. It was found that of those drivers who had not driven, 66% felt "fine" and 2% felt "tired". Of those drivers who had driven ten or more hours, only 15% felt "fine" and 50% felt "tired".

In summary, it might be concluded that insofar as various psychophysical tasks duplicate the basic requirements of driving there seems to be a relationship between length of driving time and decreased performance. However, as was pointed out on page 9, the relation between existing psychophysical measures and other criteria of driving proficiency is extremely slight.

II. INTELLECTUAL FACTORS IN RELATION TO HIGHWAY SAFETY

INTELLIGENCE As was previously mentioned, highway safety research has been primarily concerned with testing psychomotor functions in relation to accidents. Relatively little attention has been devoted to determining the relation of intellectual abilities to accidents. Few studies have been initiated exclusively to assess this relationship; conclusions must be based upon studies which included some estimate of intellectual capacity with other variables being investigated. The results are conflicting, as might be expected, because of the methodological considerations already mentioned as well as the use of different measures to estimate intellectual capacity or achievement.

In general, intellectual capacity may be estimated in two ways: (a) by tests which reflect, with varying degrees of exactness, general scholastic aptitude and (b) by indirect measures (such as occupational level or highest educational level attained) which are subject to considerable error since they are affected by a number of cultural and personality factors. It should be clear that the results of studies which have utilized different samples of the population and which have used different means to estimate intelligence are not, therefore, directly comparable.

One of the earliest attempts to relate measured intelligence to "accident proneness" in individuals used 100 traffic offenders as subjects (277). The investigators found that 42 of the subjects had "inferior intelligence". Interestingly enough, since intelligence test scores are assumed to be fairly normally distributed among the general population, one would expect that by chance alone fifty of the one hundred violators would be of "inferior" intelligence according to statistical norms.

A somewhat similar design was employed by Selling (296) who claimed to have found a median I.Q. of 77 for a group of 500 traffic offenders. It is difficult to determine how valid the results are since little information is presented regarding the tests which were used or how and by whom they were administered.

Lawshe (202) cites two studies by Lauer as being indicative of the relationship between intelligence and accident involvement. The first

(177) presented is a survey of 141 drivers which summarizes those most susceptible to accidents with respect to intelligence as follows:

I. Q. Score	% of Those Involved in Accidents
65-100 %ile	17.4%
35- 65 %ile	42.3%
1- 35 %ile	33.2%

In the second study cited (181), Lauer is reported as concluding that drivers with intelligence quotients below 75 or 80 and between 110 and 125 are more apt to have accidents than other people.

It will be noted that the figures in the above table total only 92.9% so interpretation is rendered somewhat difficult. As they stand, however, they seem to indicate that, contrary to Lauer's second statement, it is the group of *average* intelligence which is most susceptible since the middle 30 per cent of the I.Q. range accounted for 42.3 per cent of the accidents.

In addition, Ghiselli and Brown (136) failed to find any validity in the intelligence and education requirements used in the selection of motor coach operators in a city transit system.

With respect to the second method of estimating intellectual capacity, namely, years of school completed, the results are equally inconsistent. Cobb (68) found a definite and reliable relationship between years of schooling and accident frequency, those with most schooling tending to have fewer accidents. Brody (42), however, found no relationship at all. The 26 members of his accident-repeater group had a mean number of years of schooling of 10.4 as compared with a mean of 10.6 for a control group of equal size. Cobb's data would seem to be more valid in view of the relative thoroughness with which the two studies were conducted, though each study leaves something to be desired in the way of scientific rigor.

In summary, it may be assumed that intellectual factors have some effect on accident involvement. It would seem that persons who score lowest on intelligence tests tend to be invloved in more automobile accidents. The degree of importance of this relationship is not known and certainly no critical I.Q. scores can be presented to identify groups of "susceptible" drivers. Any definite statements of the relation between accidents and intelligence, based on "evidence" presently available, must be viewed with utmost skepticism.

KNOWLEDGE OF PROCEDURES Seemingly more directly relevant to a study of accident liability than a driver's intellectual ability is his actual knowledge of safe driving practices.

Although it may be presumed that drivers who have absolutely no knowledge of driving rules and procedures will be poor insurance risks it *does not follow* that knowledge of safe driving procedures necessarily has any material effect on driver behavior.

This thesis has been subjected to test by several investigators. Two of the three studies actually found that the accident group obtained *better* scores on tests of driving knowledge than did the non-accident group. The positive results were obtained by the American Automobile Association in 1939 (133) and the negative findings by the Eno Foundation for Highway Traffic Control (114) and the Personnel Research Section, Adjutant General's Office (331, p. 65).

These findings have, of course, significant implications for driver training programs. We have noted that physical characteristics have only a slight relationship to accident susceptibility. We have seen that neither high intelligence *per se* nor knowledge of safe driving practices is guarantee against accident involvement. It would seem, therefore, that the driver's attitudes, motivations, and moods must be the factors which discriminate between successful and unsuccessful operators. If this be true, then our entire driver education program must be directed toward discovering and remedying attitudes which militate against safe operation of motor vehicles. Attempts to discover these unfavorable temperament factors will be surveyed in the following section.

III. TEMPERAMENT FACTORS IN RELATION TO HIGHWAY SAFETY

Because of indications that accidents occurred to individuals which could not be explained on a chance basis some investigators directed their attention to determining personal characteristics of accident-drivers, accident-repeaters, and traffic violators. In reviewing reports of their studies some interesting results are found.

For example, the "accident prone" person possesses undesirable social traits (353) and he possesses desirable social traits (42); he is over-confident (131) and he is over-cautious (297); he is aggressive (297) and he is timid (181); he is competitive (115) but easily frustrated (115); he is unintelligent (42, 181, 277, 285, 296) but he may be quite intelligent (42); he is neurotic (296), claustrophobic (297), psychotic (181, 277, 296, 302), schizophrenic (38, 285). He is impulsive (278, 297), careless (131), reckless (57, 181), and not alert (277). He is a "ne'er do well" (181) and is drug-addicted (181) and alcoholic (277, 296). He has "bad attitudes" (115, 297) and may be excitable or depressed (285). He is self-destructive (278, 285). His personal history indicates he comes from an unstable childhood home (297, 332), his parents are divorced (332), he has had short term employments and firings (332), is uncooperative (278, 297, 312, 332) and delinquent (297, 312, 332) and is sexually promiscuous (332). In short, he is maladjusted (42).

All but one of the above studies was based on an "analysis" of a group of persons who either violated traffic laws or who had accidents. The majority of investigators seemed to be little concerned whether the characteristics they listed were also present in non-violators or non-accident drivers. This, of course, is a most serious methodological oversight, and one which could lead to quite severe consequences. The casual reader may be totally mislead by a few such articles; in fact, certain prominent workers in the area of highway safety have blithely included the results of some of the above studies to support their own rather shaky opinions concerning accident causation.

The absence of a control group is not the only criticism that may be leveled at the above studies. It should also be noted that the techniques of selecting groups for study were poor, at best. The acceptance of volunteers, for example, may introduce certain uncontrolled variables. No attempt was made to secure cross-sectional, or representative, samples; the sample size was uniformly small; insufficient controls were employed in selecting control groups in the few instances that control groups were used (one study accepted as a control group volunteers who were "assumed" to have "average" accident records, whatever this means); and in only two instances were tests of significance made. A brief summary of samples selected and tests employed is presented in Table II.

Other drawbacks of these investigations have been presented on pages 129 and 130 of the present report. The most that can be safely concluded from studies of the relation between personality characteristics and traffic accidents is that the results are inconclusive.

We might suggest as a beginning to an attack on the problem that investigators develop (a) some valid measures of certain personality "traits" and (b) an acceptable criterion measure of driving proficiency. The investigators may then turn their attention to the problems involved in the selection of adequate experimental and control groups which have heretofore been rather circumspectly avoided by many highway research personnel.

There is also possibility that *transient* attitudes may influence the driver to an extent that he becomes involved in an accident. In other words, the accident-driver may obtain "normal" scores on tests of personality when he is in a non-stressful situation, but may occasionally (1) be so late for an appointment (2) frustrated by heavy traffic or (3) emotionally disturbed by some other such stimulus that his proficiency in handling his vehicle is temporarily disturbed.

TABLE II

Summary of Certain Studies Concerned with Characteristics of Accident Prone Drivers

Bibliographic Reference	Accident Group	N	Control Group	N	Tests Used	Test of Significance Made
38	traffic violators	58	volunteers	59	Minnesota Multiphasic Personality Inventory	Yes
42	drivers with 3+ accidents	26	accident free volunteers	26	Siebrecht Scale and Bell Adjustment Inventory	No
115	unknown	..	unknown	..	Siebrecht Scale, Iowa State Multi-Attitude Scale and Non-standardized Performance Tests	No
131	accident repeaters	138	volunteers	52	Harvard Traffic Bureau Battery and Forbes Miniature Highway Test	No
181	none	..	none	..	none	No
277	violators	100	none	..	"a social investigation"	No
278	none	..	none	..	none	No
285	drivers injured in accidents	128	none	..	"analysis of circumstances of accident as a whole"	No
296	court referrals	500	none	..	"psychological and clinical tests (unspecified)	No
297	traffic offenders	300	none	..	unstandardized paper-and-pencil and performance tests	No
312	employees of elevated railway company	(unspec.)	none	..	company records	No
332	high accident drivers	20	low accident drivers	20	interviews, personal history blank and court records	No
353	random group of drivers	204	random group of drivers	470	"social data"	Yes

CONCLUSIONS

A survey has been made of the literature related to highway safety. The results of the various studies reviewed appear to justify the following conclusions:

1. *Accident-proneness.* Much of the literature on accident-proneness must be discounted because of inadequacies in the data or the procedures of analysis. Despite these limitations there appears to be a tendency for individuals to differ in their susceptibility to highway accidents.

2. *Vision.* Above a minimum level of visual acuity, vision seems to play only a very slight role in influencing accident occurrence.

3. *Psychomotor abilities.* There are no clear-cut, demonstrable relationships between measured psychomotor activities and accident occurrence. This may be due to sampling inadequacies, unreliable criteria, or imperfect measures.

4. *Physiological conditions.*

   a. Autonomic nervous system. Blood pressure, pulse rate and galvanic skin response are very slightly related to accident rate.

   b. Alcohol. Any alcohol at all consumed by the driver seems to have some effect upon accident rate.

   c. Fatigue. Length of time spent driving is strongly related to decreased performance on certain psychophysical tasks. However, the demonstrated relationship between such psychophysical tasks and the actual job of driving is extremely small.

5. *Intelligence.* There is some slight indication that persons who do relatively poorly on standard tests of intelligence tend to be involved in more automobile accidents.

6. *Knowledge of Procedures.* There is no indication that mere knowledge of safe operating rules and procedures has any effect on reduced accident rate.

7. *Temperament.* Nearly every undesirable characteristic known to mankind has been cited as the cause for accidents, but the evidence offered to support these ideas is not nearly as great as the conviction with which they are expressed. No single measurable personality variable has been found which is reliably related to the accident rate of a representative group of drivers. This statement does not imply that no relationship exists; merely that none has thus far been identified.

8. *Methodology.* An accident may be precipitated by any one of a large number of factors, or several factors in combination. It is unreasonable, therefore, to expect that any single factor, considered by itself, will show a very substantial relationship with accident rate. Many previous research studies, despite the difficulties of securing large samples and sustaining long range research programs, have discovered relationships between accident occurrence and certain other variables. It is somewhat unfortunate that these studies, valuable though they are, have led in the direction of discovering general relationships rather than toward discovering the basic *behaviors* which contribute directly to accidents. It is far less important to know what type of person has accidents than to know what persons *do* to become accident victims. It is impractical to assume that we can bar large numbers of drivers from the highways but it is entirely reasonable to state that we can attempt to alter their hazardous behaviors . . . once these behaviors are known.

TRAFFIC ENGINEERING SUPPLEMENT

INTRODUCTION During the course of abstracting the bibliographic references for the present review it was discovered that a number of reports referred to studies which were concerned with traffic engineering features. As such, they did not fit logically into the outline originally planned for the review. They are, however, of definite information-value to the Joint Safety Research Group and are summarized in the following supplement to the main report. It is to be emphasized that the studies discussed do not by any means represent all, or even a substantial portion, of that which has been discovered in any given area.

Each of the studies cited indicates the need for any study of accident causation to consider not only the driver, his vehicle, or the environmental factors present at the time but to interpret accident causation in terms of all three variables acting as a functional unit. In terms of the driver as a reference point, the investigator must consider driver behavior as it is limited by vehicle design and taxed by the immediate environment.

AUTO DESIGN Although many investigators report that the great majority of automobile accidents are due to driver error, it is quite likely that the design of the vehicle may be at least partially to blame. In other words, the automobile designer can make the driver's task easier, and thus influence the accident rate, merely by making slight changes on his blueprints.

Dunlap has pointed out that drivers who shy away from the right shoulder of the road may do so, not because of any personality characteristic of "hoggishness", but merely because they are not sure where their wheels are (106). Placing the windshield lower, building the fenders higher or providing vertical seat adjustments (247) so that the fenders could be seen from the driver's seat may overcome this tendency. It would be fairly easy to study this hypothesis. Motion picture cameras could be set up at selected locations. The cameras could be operated electronically by the passing vehicles. The autos could then be grouped according to visibility or no-visibility of front fenders and the mean lateral distances computed.

It may well be that other accidents presently attributed to driver error may also be due to the driver's inability to surmount difficulties which are inherent in his auto's design. For example, Henderson* calls attention to the driver's "self-righting reflex". If the auto enters a skid or if it is slightly bumped by another vehicle there is a tendency for the driver to grip the wheel tighter and to steady himself by bracing his legs. He may thus inadvertantly depress the accelerator pedal and compound his difficulties. The "fail-safe" principle has long been employed in designing railroad equipment. It is interesting to note the automotive industry's failure to incorporate this design feature in their product.

Additional hazardous design features are lights which fail to pierce fog (driver "error" is perceptual loss, or traveling too fast for conditions); glaring headlights (driver "error" listed in perceptual area); and protruding metal parts which serve to increase the severity of any accident. (11, 157, 241, 335)

Some automobile manufacturers have incorporated certain design features in their recent autos which provide an opportunity for controlled evaluation of these suggestions. It is now potentially possible to determine the effect of certain design features upon the driver's capabilities.

**Henderson, Y. How cars go out of control: analysis of the driver's reflexes. Science, 1935, 82, 603-606.*

ROAD SURFACE The Department of Scientific and Industrial Research in Great Britain conducted an investigation which will serve to illustrate the dramatic consequences of an environment complicating the driver's task (314). Two sections of roadway were investigated which consisted of wood blocks. In the period from November 8, 1937 to February 7, 1938 there were 63 accidents on Section A and 57 accidents on section B. Section A was then surface dressed with a "non-skid material". In the period from November 8, 1938 to February 7, 1939 there were only 4 accidents on Section A and 86 on section B. These results are even more impressive when one considers the increased rainfall during the second period (7.38″ vs. 11.23″ respectively: or 45 dry days vs. 29 dry days in the second period.)

The implications of the above study for highway safety are clear. The study indicates that when the highway engineer can simplify the drivers' task or, more accurately, can reduce the demands made upon the driver, a marked reduction in the accident rate will occur. If a means were found to maintain a completely dry, or "non-skid", roadway it seems safe to predict that there would be a considerably lower accident rate.

ROAD CURVATURE Baldwin demonstrated a relationship between degree of curvature of road and accident rate which, again, illustrates the interaction effect of the driver, the vehicle, and the environment. In investigating the accidents on two-lane highways in eight states, he discovered a steady increase in accident rate (ad-

TABLE III

Relation Between Road Curvature and Accident Rate (from Baldwin, reported in 314)

	Accidents		Accident Rate (per 1 million vehicle miles)	
° of curve/100′ rd.	Flow 5000 veh/day	Flow 5-10,000 veh/day	5000 veh/day	5-10,000 veh/day
less than 2	250	37	2.4	1.9
2-2.9	221	47	3.3	2.5
3-3.9	152	65	3.5	3.5
4-4.9	158	64	3.7	3.7
5-5.9	139	35	4.3	3.3
6-6.9	119	34	3.9	2.8
7-9.9	115	25	3.1	2.5
10-13.9	132	24	3.7	2.6
14-19.9	108	12	6.3	*
20 and over	129	13	7.6	*

**Sample considered too small for reliability.*

justed for vehicle miles and for traffic flow) and degrees of curvature per 100 feet of road (314).

The results of this investigation are presented in Table III.

Baldwin also discovered a relationship between accident rate and width of road (two-lane highways). He concluded that increasing the width of the road up to 23 feet has a definite effect on accident rates. These results are corroborated by a study cited by Lawshe (202).

The effect of curves on driver behavior has been investigated by Steinbaugh and by Thompson (cited in 202). Although their investigations were conducted on two-lane highways it is probable that the behaviors they observed are even more likely to appear on four-lane highways where the danger of head-on collisions is reduced. It was found that drivers tend to "hug" the inside of the pavement when negotiating a curve regardless of the direction of travel. More than 15% of vehicles traveling over 50 mph use the wrong side of the road in this manner.

This tendency to cut across curves is accentuated by the speed the driver is traveling. Moreover, even on straight stretches, the speed at which the driver is traveling influences his lateral position on the road. At speeds below 40 mph the average distance from the edge of the pavement for the right front wheels was found to be 4.8 feet. At speeds from 40-60 mph the distance was 6.4 feet and at speeds greater than 60 mph it was 8.6 feet.

These findings suggest an explanation for many sideswiping accidents. (One wonders whether there is a similar avoidance of the medial strip edge on the part of Turnpike drivers.) Thompson and Hebden (330) found that drivers of autos being passed tend to follow the center line of their own lane. But when passenger cars passing trucks come uncomfortably close to the left edge of the road it is as often due to their own driving habits (judgment?) as it is to their being crowded over by the passed vehicle.

ROAD LIGHTING The Ministry of Transport in Great Britain investigated changes in accident rate during various times of the day. Fatal highway accidents occurring on weekdays in England were tallied in separate hourly periods for each month of the year (1935) in order to arrive at an estimate of relative road hazards during daylight and darkness. It was found that the distributions of accidents by month of the year for particular hours of the day were not different from the distributions that would be expected to occur by random chance, except for those hourly periods which were dark for some months of the year and light for others. In these periods the ratio of accidents at night to accidents in the daytime was approximately 2 to 1. This difference is significant, indicating a stronger probability of accidents occurring at night. Since approximately 40 per cent of the accidents occur at night it would seem, on the basis of the above, that approximately 20 per cent of the total accidents could be eliminated by sufficient improvements in highway and vehicle lighting (314).

TABLE IV

Accidents in Hartford, Connecticut Before and After the Lighting in Certain Streets was Improved (307)

	Relighted Sections		Unchanged Sections		Rest of City	
	Day	Night	Day	Night	Day	Night
One Year Before	232	248	222	195	686	480
One Year After	217	133	246	203	680	477

This assumption is supported by evidence gathered in Hartford, Connecticut and reported by Simpson (307). The lighting of ten miles of street was increased from 0.18 to 0.43 lumens per square foot. The number of accidents occurring in relighted sections during the one year period following the change was about half the number occurring in the preceding year. Accident frequencies in unchanged areas remained fairly constant.

An interesting comparison is the per cent of total accidents occurring in Great Britain during a one year period (314) under varying light conditions with the per cent occurring on the Pennsylvania Turnpike during its first 11 years of operation. To serve as a reference, the per cent of each 24 hour period classified by light conditions was abstracted from the World Almanac. These data are presented in Table V.

TABLE V

Per Cent of Total Accidents Occurring Under Various Light Conditions

	Per Cent of Total Accidents		
	Turnpike	Great Britain	Per Cent of Day
Daylight	58	57	51
Dusk-Dawn	5	5	14
Night	37	38	35

Of course, the above table gives no information about vehicle miles driven under the various light conditions but the similarity is striking for the two regions. This is especially so when one considers the disparity of conditions between the two locations; weather and road differences, lack of illumination on the Turnpike, etc.

ROAD SIGNS A considerable number of studies have been carried out to investigate the effects of color, shape, legend, reflectorization, size, emphasis, location and standardization of signs but the actual *effect,* in terms of accident reduction, has received little attention in formal publications.

Eliot (110) cites the results of a survey conducted in Rhode Island which indicated that 42 per cent of drivers failed to slow to 15 mph at locations controlled by a flashing amber light. Other surveys cited in the same report indicated that from 22 per cent to 62 per cent of drivers fail to make a complete stop at standard stop signs.

On the other hand, results of informal surveys, such as those presented in the Iowa State College Driving Laboratory News, frequently cite "significant decreases in accidents after installation" of sign equipment.

It is difficult for a person who has any faith at all in the human being as a rational animal to believe that appropriate signs, well placed, will fail to have an effect on accident rate. Every bit of information that is communicated to the driver must of necessity increase his ability to cope with the driving situation immediately at hand. The requirements for a "valuable" sign in this regard are (a) that it be legible under all weather conditions and at all speeds and (b) that it communicate a message which seems reasonable to the driver. An example of a sign which does not fulfill the latter requirement is a "reduced speed" sign along a roadway where there is absolutely no visible hazard. In such cases an "explanation" to the driver of the necessity for more caution is clearly obligatory.

SUMMARY The traffic engineering supplement has presented the results of representative studies concerned with the effect of auto design, road surface, curvature, width, and lighting upon accident occurrence. The results cited indicate the many important contributions made by traffic engineers in reducing the accident rate. But highway accidents continue to occur. Without minimizing in any way the significance of engineering efforts it can be stated that more work can and should be done on the accident problem.

The use of psychological tests has been sufficiently successful to indicate that certain minimal standards are desirable for applicants for drivers' licenses, e.g., tests of vision, reaction time, etc. In addition, the preliminary work that has been done in investigating the relation between personality characteristics and accidents indicates that future, carefully conducted, research may yield important advances. It is believed that new developments in research methods will uncover data which has hitherto been partially obscured by non-standard terminology. For example, a detailed classification of actual driver behaviors which directly contributed to the occurrence of an accident should do much to clear the air of speculation and surmise. A study of these behaviors in the context of weather and road conditions facing the driver at the time of the accident should serve to indicate avenues of attack on the problem of reducing highway accidents. There is no satisfactory substitute for such factual data as a source of hypotheses to be investigated.

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APPENDIX B

FIELD SURVEYS

I. BASE LINE DATA
II. ACCIDENT INVESTIGATION
III. GENERAL FIELD OBSERVATIONS

FIELD SURVEYS

INTRODUCTION This section of the report is set aside for the coverage of the field survey work. That field work dealing with the "Near Accident" interviews has been made part of Chapter II.

The activities of the field group covered:

- I. *Base Line or Exposure Data*
  - A. Speed Survey
  - B. Traffic Flow and Composition
  - C. Weather
  - D. Curve Rating
  - E. Roadway Element and Place Division
- II. *Accident Investigations*
- III. *General Field Observations*
  - A. Maintenance
  - B. Police
  - C. Radio System
  - D. Signing

BRIEF SUMMARY:

I. *Base Line or Exposure Data*

A. Speed Survey

The speed data served to give answers regarding the question of speed, and served as a good indicator of the drivers' recognition or lack of recognition of environmental cues calling for various degrees of caution.

The survey showed that passenger cars were traveling under good weather and road conditions at a "10 mile pace speed" (10 mile per hour spread at which most cars travel) of 53 to 63 miles per hour. This 10 mile pace for trucks was 45 to 55 miles per hour.

A point of importance is that drivers do not reduce speed appreciably on wet roads—indicating they do not consider this condition a potentially great hazard. Further, truck drivers slow down slightly on icy roads as compared to wet or dry pavement. The passenger car driver, on the other hand, recognizes the hazard in snowy and icy roadway as evidenced by an average 10 miles per hour reduction in speed under these conditions.

B. Traffic Flow and Composition

The traffic flow data allows appraisal of various accident categories and has been used in this manner.

The data collected permitted a close estimate of the ratio of day-to-night average traffic flow. The estimates indicate that during the six month period between the middle of October and the middle of April, about 40% of the overall traffic flow takes place. Further, the day traffic runs close to 1.4 times the night time and twilight hour traffic during this same period. A close estimate shows these figures to run 60% and 1.6:1, respectively, for the remaining period of the year.

C. Weather

As in the case of all base line information, the weather data permitted approximate ratings of the accidents according to weather. This same information, together with the Turnpike's road condition reports, made possible close estimates of the road surface condition exposures.

Close estimates established for 1952 showed the weather condition breakdown to run as follows:

Clear or Cloudy	82.8%
Precipitation (rain, snow, sleet, hail)	17.3%
Fog (visibility ¼ mile or less)	3.0%

From this and road reports the estimates of roadway conditions ran:

Dry	77%
Wet	18%
Snow or Slush	2%
Ice or Icy Spots	3%

D. Curve Rating

The main point of interest here is that roughness of pavement, as well as length of curve, degree of curvature, and amount of superelevation, determined whether the curve was rated as one appearing to require driving effort. This data is available for further detailed study should this phase of study be deemed necessary.

E. Roadway Element and Place Division

These values were set up to show the degree of main line exposure according to roadway element so as to establish a basis for appraising accidents from that standpoint.

The breakdown is as follows:

Base Line Percentages According to Place

*Place	% miles
1. Interchange Areas	4.4
2. Service Station	3.4
3. Tunnel Portal	.4
4. Tunnel Approach	1.5
5. In Tunnel	2.4
6. Bridges	.9
7. Main Line Normal	87.0

*NOTE: These are % of miles of the main road passing interchange areas, service station areas, etc.

II. *Accident Investigations*

The actual "on-the-scene" witnessing of accidents served two purposes. First, it gave the research group first-hand knowledge regarding accidents thereby building up a judgment factor which aided in considering the various phases of accidents. Secondly, the resulting reports, when later compared with the police reports covering the same accidents, permitted an evaluation of the over-all police report data being used for the research.

Suffice it to say that this experience aided the program materially and indicated that the data taken from past police reports is entirely adequate for the part it is playing in the study.

III. *General Field Observations*

Some of the observations made substantiate past discussions. For example, in the case of police, it was noted that legal requisites such as attending hearings, which take place some distance from the Turnpike, cut into the patrolman's time on the highway.

Also, certain other items have been noted, some of which have since been in the process of correction. For example, at curves where it has been difficult to maintain the berm even with the edge of the road, steps have been taken to stabilize the berm with asphalt.

FIELD SURVEY DETAILS

I. *Base Line Data*

A. Speed Survey

Seventy-nine tests, each lasting from 1 to 3 hours, were made between early February, 1953 and the end of June, 1954. Test locations were selected throughout the entire length of the Turnpike so as to cover the various types of terrain and to include both the 60 and 70 m.p.h. speed limit zones.

The speed of approaching traffic was measured by radar equipment from a point on the berm about 10 feet from the edge of the concrete. The equipment was set up in the trunk of a passenger car. The trunk lid was left open and the automobile was disguised as a vehicle with mechanical trouble. This was done so as not to alter the driving habits of the traffic as it approached the parked vehicle. The camouflage proved to be effective. In fact, on quite a number of occasions both police and maintenance personnel stopped to see if the "patrons" needed any help. Two observers were used, one to read the "speed meter" and the other to spot the type of vehicle and record the data on a chart in the form of distribution curves. (See Appendix F for sample speed distribution curve.)

Separate curves were plotted for passenger and for commercial traffic. A distinction was also made between the larger tractor-semi-trailers and the smaller commercial vehicles within the actual commercial speed distribution curves. The separation between passenger cars and commercial vehicles was necessary since there is a difference between their basic driving habits and the laws under which the two groups operate. Approximately 17,600 passenger vehicles and 9,900 commercial vehicles, or a total of about 27,500 vehicles were observed.

On the basis of the above tests (which were largely limited to the late winter and early spring seasons) passenger car traffic traveled with median speeds in the range of 56 to 60 m.p.h. in the 60 m.p.h. zone on straight and level (±0.50% Grade) dry roadway, and only slightly faster with median speeds in the range of 58 to 64 m.p.h. in the 70 m.p.h. zone. Commercial vehicles were observed to travel with median speeds in the range of 46 to 52 m.p.h. in both the 45 and 50 m.p.h. zones under similar conditions. In addition, there are indications that trucks travel slightly faster at night than during daylight, perhaps because the traffic density is less during the darkness hours.

The table below shows data taken from two typical tests.

Date—2-26-53 Speed Limit Zone—60/45 m.p.h.
Milepost 109.2 Eastbound (Somerset Area)
Weather—Clear; Roadway—Dry, Straight, Level (± 0.50% Grade)

	Passenger Vehicles	Commercial Vehicles
10 Mile Pace	53-63 m.p.h.	45-55 m.p.h.
2 Percentile	44 m.p.h.	38 m.p.h.
85 Percentile	64 m.p.h.	54 m.p.h.
98 Percentile	70 m.p.h.	60 m.p.h.

Date—3-9-53 Speed Limit Zone—60/45 m.p.h.
Milepost 68.2 Eastbound (Irwin Area)
Weather—Cloudy; Roadway—Icy, Cindered, 1.66% Downgrade, Straight

	Passenger Vehicles	Commercial Vehicles
10 Mile Pace	41-51 m.p.h.	37-47 m.p.h.
2 Percentile	32 m.p.h.	34 m.p.h.
85 Percentile	54 m.p.h.	48 m.p.h.
98 Percentile	62 m.p.h.	54 m.p.h.

Insofar as weather and its effect on driving speeds is concerned, observations indicate that the median speed for passenger cars drops only slightly, to 54 to 58 m.p.h., for wet roadway and light rain. However, speeds drop to about 45 m.p.h. on snowy, slushy, or icy roadway. Commercial vehicles, on the other hand, showed practically no speed reduction on wet roads or in rain. They did reduce their speeds, but only slightly, for icy roads with median speeds being observed in the range of 42 to 44 m.p.h. under these conditions.

On steep down-grades passenger cars did not travel much differently than on straight and level roadway. On long up-grades, passenger vehicles appeared to travel with median speeds of the order of 45 m.p.h. This is probably not as accurate a figure as the general data, however, since the only up-grade test data was taken under somewhat less than favorable conditions.

There was a tendency for commercial vehicles to travel a few miles per hour faster on steep down-grades than on straight and level roadway. On steep up-grades the median speeds for commercial vehicles dropped to about 22 m.p.h.

There are indications that, on Sunday afternoons and evenings, the median speeds observed for passenger cars might be a few miles per hour below the median speeds for the other days of the week. Commercial vehicles, on the other hand, showed less of this tendency. The passenger car speed reduction is not necessarily a "Sunday Driver Habit", but might be a result of the heavier traffic density which usually exists on Sundays.

To sum up the results of the speed survey, it might be said that the only factor which seriously affected the speed of vehicles on the highway was a slippery road. It may be further said that passenger car drivers appeared to recognize the increased demands of slippery roads to a greater extent than commercial drivers. For some reason neither passenger or commercial drivers recognized or respected the task involved while driving on wet roadway, steep downgrades or while driving after dark.

A sample speed curve is included in Appendix F of the report. Due to the bulk of these curves, they have been excluded from the appendix. They are available, however, at the Pennsylvania Turnpike Commission, Harrisburg, Pa.

B. Traffic Flow and Composition

An automatic traffic count recorded the combined hourly passenger car and truck vehicle count in the westbound lane at Harrison City Maintenance Building. These data, along with the traffic density measurements that were taken during the speed checks and axle counter readings at tunnels, were tabulated and facilitated an analysis of the day to night ratio of traffic flow. In addition, a tabulation of traffic flow by day of week was prepared for comparison with a similar tabulation compiled from accident data. For further information the reader is referred to Chapter I.

C. Weather

Two years of weather bureau records (1951 and 1952) from several weather stations throughout the length of the Turnpike were microfilmed and abstracted to show the number of hours and the character of precipitation for the one plateau and mountainous section of the Turnpike. Also tabulated were the number of hours when visibility was less than ¼ mile and the number of hours of below freezing temperature. Since these sections of the Turnpike are made up of both plateau and mountainous areas and the weather experience on both was close for the two years studied (and in line with general weather charted), it was considered that the weather over those portions of the highway would be a fair approximation of the average weather. Weather bureau data was used to arrive at an estimate of the weather for the two-year period in terms of the number of hours of clear weather, rain, snow, etc., for both day and night. After a comparison of the two years' weather it was found that there were no large differences in the weather for these two years. An estimate of roadway condition was then established by combining the 1952 weather bureau data with the roadway condition information for 1952 as gathered by the radio operators at Everett. This resulted in an estimate of the number of hours of dry, wet, snow and ice covered road for both day and night. On the whole these data should also be a close estimate of roadway conditions for the entire Turnpike. This was substantiated by taking into account the data on the road reports, and by comparing the overall monthly summaries of the section studied with the monthly summaries for the remaining sections.

D. Curve Classification

The field group drove the entire length of the Turnpike in both directions for the purpose of classifying each curve according to the effort required to negotiate it at 65 to 75 miles per hour. The automobile used was a 1953 Plymouth Sedan. In general, most curves could be driven with little effort at these speeds. However, there are several factors in addition to the degree of curvature which had a decided effect on the classification. The superelevation on some curves of equal curvature did not appear to be as effective as on others. Roughness was a factor in determining the ease with which a given curve could be negotiated, since a rough spot, such as a bridge approach which had settled, required compensation by the driver. It was found also that some long curves required more effort than shorter curves of the same curvature. This probably was the result of the longer effort time required by the driver. These data are available for future use in analysis of accidents with regard to particular locations.

E. Roadway Element, Place, and Daylight Distribution Analysis

A tabulation was prepared to show the total mileage of curves with various degrees of curvature as compared to the total mileage of straight roadway. A similar tabulation was prepared showing the percentage of highway with various combinations of grade and curvature. A third tabulation was prepared to list the percentage of highway at interchange areas, tunnel approaches, service stations, etc. Another tabulation showing the hours of daylight, darkness, and twilight was also prepared. All of these data have been used in the various statistical operations for comparison of accidents occurring under various conditions.

II. *Accident Investigations*

The field group visited the scene of about two dozen accidents and prepared reports on these for comparison with the corresponding police accident reports. The purpose of this was not only to check on the accuracy of the police reports, but also to develop some idea of the speeds at which accidents are set up and to learn, first hand, as much as possible about the conditions under which accidents occur. On a number of occasions, the field group was able to talk with the driver involved prior to the arrival of the investigating officer. A great deal of first-hand information was received in this manner. Accidents have been observed over the entire length of the Turnpike and have ranged in severity from very minor scratched fenders to a severe multiple fatality. In only one accident was there any serious disagreement between the report by the police and the information observed at the scene by the field survey group. The other reports agree very closely with the facts collected at the accident scenes. In most cases the speed at which trouble was first noticed was reported by the officer to be of the same order as that estimated by the field group. A review of the reports by project psychologists indicated that the drivers' and officers' statements are reliable in so far as the psychological information is concerned. It was noticed that reports of the more serious accidents were more complete in detail.

III. *General Observations*

Before starting work on the highway the field group spent two weeks with the Safety Engineer for the Turnpike, during which time various members of the maintenance and police organizations were met. The group was thus in a position to gain first-hand knowledge of highway operation. At the same time the field group attended first-aid classes so as to be of maximum assistance at accidents.

All of the field observational work was carried out continuously along with the other work of the field group. The extent of this work is best indicated by the fact that some 20,000 miles were covered by this group in less than 10 months.

The field observations have been used in verifying the results of the analytical work. In those cases where information had no direct connection with safety research, it was reported to the Turnpike Commission for eventual benefit to the Turnpike patron.

APPENDIX C

ENVIRONMENTAL SECTION

I. VEHICLE INVOLVEMENT FREQUENCY TABLES

II. CONTINGENCY TABLES (Relationships Between Environmental Conditions and Related Factors)

I

VEHICLE INVOLVEMENT FREQUENCY TABLES

Light Conditions
Weather Conditions
Roadway Conditions
Roadway Element

TABLE C-1

Percent of Passenger Car Involvement in Accidents: How Vehicle Was Involved By Light Conditions (1941-1952 Data)

		PERCENT OF TOTAL					
HOW VEHICLE WAS INVOLVED	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Pedestrian	45	55.6	42.2	—	2.2	—	100
Rear End	2620	55.4	32.7	4.8	6.0	1.1	100
Stopping, Stopped, Parked	369	50.9	36.1	6.5	6.2	.3	100
Medial Strip	726	66.7	25.6	4.7	2.2	.8	100
Coll. W/Obj. Other Than Vehicle	966	57.9	32.9	5.3	3.3	.6	100
Overturning	943	66.6	26.3	5.8	.9	.4	100
Fire Only	64	65.6	25.0	7.8	—	1.6	100
Running Off Roadway	396	60.4	29.8	8.6	1.0	.2	100
Sideswiping	571	63.7	27.5	5.4	3.0	.4	100
Others	284	64.0	25.4	6.0	2.8	1.8	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-2

Percent of Truck Involvement in Accidents: How Vehicle Was Involved By Light Conditions (1941-1952 Data)

		PERCENT OF TOTAL					
HOW VEHICLE WAS INVOLVED	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Pedestrian	17	41.2	52.9	—	—	5.9	100
Rear End	1859	42.8	46.4	4.8	5.1	1.0	100
Stopping, Stopped, Parked	372	34.1	44.1	8.6	12.9	.3	100
Medial Strip	221	58.8	34.9	3.6	1.8	.9	100
Coll. W/Obj. Other Than Vehicle	284	43.0	44.0	5.6	7.0	.4	100
Overturning	296	48.0	40.5	6.1	4.7	.7	100
Fire Only	206	37.8	54.4	3.9	2.9	1.0	100
Running Off Roadway	105	57.1	34.3	4.8	1.9	1.9	100
Sideswiping	356	55.3	35.7	6.2	2.2	.6	100
Others	188	55.8	33.0	4.8	4.8	1.6	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-3

Percent of Passenger Car Involvement in Accidents: Day of Week By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
DAY OF WEEK	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Sunday	1486	55.1	34.4	5.5	4.0	1.0	100
Monday	874	59.2	29.9	7.4	3.0	.5	100
Tuesday	685	63.9	25.9	5.9	3.5	.8	100
Wednesday	745	60.4	29.5	5.1	3.5	1.5	100
Thursday	773	65.2	26.5	4.4	3.5	.4	100
Friday	993	56.8	34.9	4.5	3.5	.3	100
Saturday	1428	61.1	28.1	5.0	4.8	1.0	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-4

Percent of Truck Involvement in Accidents: Day of Week By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
DAY OF WEEK	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Sunday	508	47.2	43.0	4.5	4.3	1.0	100
Monday	476	40.8	48.7	4.2	5.9	.4	100
Tuesday	537	48.8	41.2	4.8	4.8	.4	100
Wednesday	624	42.8	42.8	6.8	6.3	1.3	100
Thursday	611	46.8	39.0	5.7	8.2	.3	100
Friday	619	44.4	46.4	5.0	3.7	.5	100
Saturday	529	45.6	43.7	5.4	3.2	2.1	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-5

Percent of Passenger Car Involvement in Accidents: Place of Occurrence By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
PLACE	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Normal	5674	59.9	32.4	5.5	1.6	.6	100
Interchange Area	631	58.8	30.7	4.6	5.4	.5	100
Gas Station Area	209	69.4	13.4	2.4	14.4	.6	100
Tunnel Approach and Portal	230	55.2	10.0	8.3	23.5	3.0	100
In Tunnel	149	48.3	4.7	3.4	35.6	8.0	100
Major and Minor Bridge	91	49.4	40.7	5.5	4.4	—	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-6

Percent of Truck Involvement in Accidents: Place of Occurrence By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
PLACE	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Normal	3149	45.2	46.4	5.3	.1	3.0	100
Interchange Area	308	43.8	5.8	4.5	45.1	.6	100
Gas Station Area	227	46.7	26.0	4.0	22.5	.8	100
Tunnel Approach and Portal	132	45.5	24.3	9.8	15.9	4.5	100
In Tunnel	60	46.7	28.4	6.6	8.3	10.0	100
Major and Minor Bridge	28	39.3	—	—	60.7	—	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-7

Percent of Passenger Car Involvement in Accidents: Number of Vehicles Involved By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
NUMBER OF VEHICLES	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
1 Vehicle	2494	61.6	29.7	6.2	1.9	.6	100
2 Vehicles	3549	58.4	32.0	5.0	3.8	.8	100
3 or More Vehicles	937	59.0	26.5	4.7	8.6	1.2	100
Unknown	4	—	—	—	25.0	75.0	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-8

Percent of Truck Involvement in Accidents: Number of Vehicles Involved By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
NUMBER OF VEHICLES	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
1 Vehicle	887	43.6	45.9	4.8	4.6	1.1	100
2 Vehicles	2581	45.6	42.9	5.5	5.3	.7	100
3 or More Vehicles	433	46.9	40.6	5.1	6.5	.9	100
Unknown	3	—	100.0	—	—	—	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-9

Percent of Passenger Car Involvement in Accidents: State of Registration By Light Conditions (1941-1952 Data)

STATE OF REGISTRATION	No.	PERCENT OF TOTAL Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
In State	2823	56.3	33.0	5.9	4.0	.8	100
Out of State	4094	62.0	28.5	5.1	3.7	.7	100
Unknown	67	58.2	37.3	1.5	3.0	—	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-10

Percent of Truck Involvement in Accidents: State of Registration By Light Conditions (1941-1952 Data)

STATE OF REGISTRATION	No.	PERCENT OF TOTAL Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
In State	1670	44.5	44.4	5.3	4.8	1.0	100
Out of State	2166	45.6	42.9	5.2	5.5	.8	100
Unknown	68	50.0	33.8	7.4	7.4	1.4	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-11

Percent of Passenger Car Involvement in Accidents: Sex of Driver By Light Conditions (1941-1952 Data)

SEX OF DRIVER	No.	PERCENT OF TOTAL Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Female	1020	69.9	21.5	5.4	2.5	.7	100
Male	5848	57.9	31.8	5.4	4.1	.8	100
Unknown	116	55.2	38.8	2.6	2.6	.8	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-12

Percent of Passenger Car Involvement in Accidents: Age of Driver By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
AGE OF DRIVER	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
16-25	2209	53.1	36.4	5.8	3.8	.9	100
26-35	1981	58.2	31.3	5.9	4.1	.5	100
36-45	1221	62.3	28.9	5.0	2.9	.9	100
46-55	827	67.3	21.9	4.7	4.6	1.5	100
56-Over	544	76.3	15.3	4.4	3.7	.3	100
Unknown	202	52.0	40.6	3.0	4.0	.4	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-13

Percent of Truck Involvement in Accidents: Age of Driver By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
AGE OF DRIVER	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
16-25	846	46.3	41.8	6.1	5.4	0.4	100
26-35	1629	42.1	46.6	4.6	5.7	1.0	100
36-45	930	47.4	41.5	5.3	4.6	1.2	100
46-55	304	51.6	39.2	5.3	3.6	.3	100
56-Over	66	60.6	27.4	9.0	1.5	1.5	100
Unknown	129	37.2	46.5	7.0	8.5	0.8	100
Total	3904	45.2	43.4	5.3	5.3	0.8	100

TABLE C-14

Percent of Passenger Car Involvement in Accidents: Estimated Initial Speed By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
EST. INITIAL SPEED	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
0	1128	52.0	33.4	5.1	8.1	1.4	100
1-10	223	61.0	27.4	4.9	5.4	1.3	100
11-20	279	62.7	26.5	4.3	5.7	.8	100
21-30	619	57.2	29.7	5.7	6.1	1.3	100
31-40	1328	57.8	31.5	5.4	4.8	.5	100
41-50	1757	61.1	31.1	5.5	1.6	.7	100
51-60	1134	64.0	28.9	5.3	1.2	.6	100
61-70	473	66.0	26.0	7.0	.8	.2	100
71-Over	43	74.4	23.3	—	2.3	—	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-15

Percent of Truck Involvement in Accidents: Estimated Initial Speed By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
EST. INITIAL SPEED	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
0	978	41.6	42.5	6.4	8.9	.6	100
1-10	324	49.4	34.9	4.6	9.2	1.9	100
11-20	494	48.4	43.9	3.9	2.8	1.0	100
21-30	553	47.7	40.0	4.5	6.5	1.3	100
31-40	904	42.3	48.0	5.6	3.3	.8	100
41-50	581	47.8	45.1	5.2	1.4	.5	100
51-60	59	49.2	45.7	5.1	—	—	100
61-Over	11	50.0	40.0	10.0	—	—	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-16

Percent of Passenger Car Involvement in Accidents: Roadway Conditions By Light Conditions

(1941-1952 Data)

ROADWAY CONDITIONS	No.	PERCENT OF TOTAL					
		Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Dry	3667	60.3	29.4	5.5	4.5	.3	100
Wet	1292	61.2	28.6	5.1	3.9	1.2	100
Snow	447	63.5	28.2	5.4	2.5	.4	100
Ice	1496	55.6	35.8	5.6	2.5	.5	100
Slush	52	82.7	11.5	—	5.8	—	100
Total	6984	59.6	30.4	5.4	3.8	.8	100

TABLE C-17

Percent of Truck Involvement in Accidents: Roadway Conditions By Light Conditions

(1941-1952 Data)

ROADWAY CONDITIONS	No.	PERCENT OF TOTAL					
		Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Dry	2371	44.4	44.8	4.8	5.7	.3	100
Wet	614	41.9	44.6	6.5	5.9	1.1	100
Snow	241	61.4	29.9	6.2	2.5	—	100
Ice	638	45.6	43.1	6.0	3.9	1.4	100
Slush	22	68.2	31.8	—	—	—	100
Unknown	18	5.5	22.2	—	11.1	61.2	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-18

Percent of Passenger Car Involvement in Accidents: Roadway Element By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
ROADWAY ELEMENT	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Straight Level	2612	61.1	27.5	5.5	5.1	.8	100
Straight Up	1064	57.1	34.7	2.8	5.2	.2	100
Straight Down	1496	60.9	28.5	4.1	5.7	.8	100
Curved Level	310	59.7	32.6	2.6	5.1	—	100
Curved Up	441	57.4	36.3	1.1	5.0	.2	100
Curved Down	880	57.9	33.7	1.5	6.6	.3	100
Others	181	56.4	28.2	3.3	3.3	8.8	100
Total	6984	59.6	30.4	3.8	5.4	.8	100

TABLE C-19

Percent of Truck Involvement in Accidents: Roadway Element By Light Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
ROADWAY ELEMENT	No.	Daylight	Darkness Highway Unlighted	Dusk & Dawn	Darkness Highway Lighted	Others	Total
Straight Level	1296	45.5	40.0	6.3	7.3	.9	100
Straight Up	952	38.1	54.0	5.2	2.3	.4	100
Straight Down	803	50.1	37.7	4.1	7.6	.5	100
Curved Level	106	50.0	39.6	1.9	5.7	2.8	100
Curved Up	286	50.3	42.0	5.6	1.4	.7	100
Curved Down	382	49.0	42.4	4.5	3.9	.2	100
Others	79	31.7	44.3	10.1	3.8	10.1	100
Total	3904	45.2	43.4	5.3	5.2	.9	100

TABLE C-20

Percent of Passenger Car Involvement in Accidents: How Vehicle Was Involved By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
HOW VEHICLE WAS INVOLVED	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Pedestrian	45	71.1	11.1	11.1	6.7	—	100
Rear End	2620	66.6	14.3	13.8	4.2	.6	100
Stopping, Stopped, Parked	369	67.2	16.5	13.6	1.9	.8	100
Medial Strip	726	52.0	25.4	18.4	1.7	1.4	100
Coll. W/Obj. Other Than Vehicle	966	68.8	19.7	9.2	1.6	.6	100
Overturning	943	71.5	17.0	9.0	1.8	.6	100
Fire Only	64	93.8	1.6	—	3.1	—	100
Running Off Roadway	396	63.9	25.8	8.5	1.3	.5	100
Sideswiping	571	72.3	13.0	11.7	2.1	.4	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-21

Percent of Truck Involvement in Accidents: How Vehicle Was Involved By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
HOW VEHICLE WAS INVOLVED	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Pedestrian	17	70.6	17.6	5.9	—	—	100
Rear End	1859	72.4	11.9	9.5	5.1	.6	100
Stopping, Stopped, Parked	372	71.5	13.2	11.5	3.5	—	100
Medial Strip	221	47.5	19.0	24.8	7.7	.5	100
Coll. W/Obj. Other Than Vehicle	284	76.8	12.7	7.0	3.2	—	100
Overturning	296	70.3	16.6	8.8	3.0	1.0	100
Fire Only	206	93.2	2.4	1.9	1.5	—	100
Running Off Roadway	105	75.2	17.1	6.7	1.0	—	100
Sideswiping	356	70.3	10.4	15.4	2.5	1.1	100
Others	188	71.8	14.4	9.0	3.2	—	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-22

Percent of Passenger Car Involvement in Accidents: Day of Week By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
DAY OF WEEK	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Sunday	1486	64.3	18.8	14.1	1.5	.6	100
Monday	874	71.2	16.7	8.1	2.9	.9	100
Tuesday	685	66.3	18.7	11.6	2.0	1.0	100
Wednesday	745	65.6	13.6	16.2	3.5	.3	100
Thursday	773	70.5	16.0	11.4	1.8	.3	100
Friday	993	65.4	17.6	12.3	3.3	.9	100
Saturday	1428	67.5	16.1	11.4	4.1	.7	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-23

Percent of Truck Involvement in Accidents: Day of Week By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
DAY OF WEEK	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Sunday	508	66.4	16.5	12.8	3.3	.2	100
Monday	476	68.9	16.1	8.8	5.0	.6	100
Tuesday	537	72.6	11.9	11.0	4.3	—	100
Wednesday	624	70.2	12.0	10.1	6.3	.8	100
Thursday	611	76.7	10.9	9.3	3.1	—	100
Friday	619	72.4	11.8	9.7	3.7	1.3	100
Saturday	529	76.0	9.3	11.0	3.0	.6	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-24

Percent of Passenger Car Involvement in Accidents: Place of Occurrence By Weather Conditions

(1941-1952 Data)

PLACE	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Main Line Normal	5674	66.8	16.8	12.6	2.8	.7	100
Interchange Area	631	69.4	15.7	10.1	3.2	1.3	100
Gas Station Area	209	75.6	17.7	6.2	.5	—	100
Tunnel Approach or Portal.	230	64.8	18.3	13.0	2.6	—	100
Major and Minor Bridge . . .	91	52.7	23.1	17.6	5.5	1.1	100
In Tunnel	149	64.4	19.4	9.4	3.4	—	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-25

Percent of Truck Involvement in Accidents: Place of Occurrence By Weather Conditions

(1941-1952 Data)

PLACE	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Normal	3149	71.9	12.2	10.7	4.2	.6	100
Interchange Area	308	75.3	11.4	7.8	5.5	—	100
Gas Station Area	227	74.4	14.5	9.3	1.8	—	100
Tunnel Approach and Portal	132	65.2	13.6	13.6	4.6	—	100
In Tunnel	60	70.0	23.4	3.3	—	—	100
Major and Minor Bridge . . .	28	64.4	21.4	7.1	7.1	—	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-26

Percent of Passenger Car Involvement in Accidents: Number of Vehicles By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
NUMBER OF VEHICLES	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
1 Vehicle	2494	68.7	19.5	9.3	1.7	.6	100
2 Vehicles	3549	69.0	13.7	13.0	3.4	.5	100
3 or More Vehicles	937	55.0	22.3	17.1	3.8	1.3	100
Unknown	4	100.0	—	—	—	—	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-27

Percent of Truck Involvement in Accidents: Number of Vehicles By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
NUMBER OF VEHICLES	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
1 Vehicle	887	77.9	12.1	6.7	2.4	.2	100
2 Vehicles	2581	72.8	11.1	11.4	3.6	.7	100
3 or More Vehicles	433	54.8	21.7	12.0	10.6	.2	100
Unknown	3	100.0	—	—	—	—	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-28

Percent of Passenger Car Involvement in Accidents: State of Registration By Weather Conditions

(1941-1952 Data)

STATE OF REGISTRATION	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
In State	2823	66.9	17.6	11.5	2.9	.5	100
Out of State	4094	67.1	16.6	12.7	2.5	.8	100
Unknown	67	67.2	10.4	13.4	9.0	—	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-29

Percent of Truck Involvement in Accidents: State of Registration By Weather Conditions

(1941-1952 Data)

STATE OF REGISTRATION	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
In State	1670	72.1	12.8	10.5	3.3	.7	100
Out of State	2166	72.0	12.3	10.1	4.8	.4	100
Unknown	68	67.7	11.8	13.2	2.9	—	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-30

Percent of Passenger Car Involvement in Accidents: Sex of Driver By Weather Conditions

(1941-1952 Data)

SEX OF DRIVER	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Female	1020	67.9	17.0	11.4	2.6	.4	100
Male	5848	66.7	17.1	12.3	2.8	.7	100
Unknown	116	72.5	10.4	12.9	1.7	1.7	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-31

Percent of Passenger Car Involvement in Accidents: Age of Driver By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
AGE OF DRIVER	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
16-25	2209	67.8	16.8	12.1	2.6	0.5	100
26-35	1981	65.5	17.5	12.8	3.1	0.7	100
36-45	1221	66.8	16.6	11.9	3.1	0.9	100
46-55	827	68.7	17.3	11.4	2.0	0.5	100
56-Over	544	68.8	16.7	10.7	2.9	0.2	100
Unknown	202	62.9	13.8	17.8	2.0	1.5	100
Total	6984	67.0	16.9	12.2	2.8	0.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-32

Percent of Truck Involvement in Accidents: Age of Driver By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
AGE OF DRIVER	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
16-25	846	75.8	12.0	6.8	4.5	.5	100
26-35	1629	70.9	13.1	10.3	4.6	.5	100
36-45	930	71.3	13.0	11.1	3.4	.5	100
46-55	304	69.7	12.2	15.5	2.3	.3	100
56-Over	66	74.2	12.2	6.1	4.5	1.5	100
Unknown	129	69.3	4.7	19.7	4.7	.8	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-33

Percent of Passenger Car Involvement in Accidents: Estimated Initial Speed By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
ESTIMATED INITIAL SPEED	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
0	1128	68.2	15.0	12.6	3.0	.4	100
1-10	223	65.0	15.7	12.6	6.3	—	100
11-20	279	51.6	19.0	23.7	4.6	.7	100
21-30	619	52.2	15.7	26.6	4.2	1.0	100
31-40	1328	60.9	15.7	18.9	3.3	1.1	100
41-50	1757	68.3	19.3	9.5	1.9	.7	100
51-60	1134	75.8	18.5	2.8	1.7	.5	100
61-70	473	82.2	14.9	.6	1.9	.2	100
71-Over	43	90.7	7.0	—	2.3	—	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-34

Percent of Truck Involvement in Accidents: Estimated Initial Speed By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
ESTIMATED INITIAL SPEED	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
0	978	70.7	13.4	11.0	4.1	.5	100
1-10	324	64.2	12.0	17.7	4.6	.6	100
11-20	494	67.2	10.5	16.8	4.5	—	100
21-30	553	68.9	13.2	11.2	5.3	.5	100
31-40	904	73.1	13.4	8.5	3.9	.8	100
41-50	581	82.1	11.0	2.9	3.1	.5	100
51-60	59	84.7	11.9	—	3.4	—	100
61-Over	11	90.0	10.0	—	—	—	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-35

Percent of Passenger Car Involvement in Accidents: Light Conditions By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
LIGHT CONDITIONS	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Daylight	4164	70.4	16.9	10.6	1.5	.6	100
Dusk & Dawn	376	63.8	15.7	12.0	7.2	1.3	100
Darkness Highway Lighted	267	68.5	14.6	10.1	4.5	—	100
Darkness Highway Unlighted	2122	61.3	17.6	16.0	4.2	.8	100
Others	55	41.8	16.4	3.6	—	—	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-36

Percent of Truck Involvement in Accidents: Light Conditions By Weather Conditions

(1941-1952 Data)

		PERCENT OF TOTAL					
LIGHT CONDITIONS	No.	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Daylight	1764	74.4	12.0	11.0	2.1	.4	100
Dusk & Dawn	207	63.8	12.6	11.0	9.7	2.9	100
Darkness Highway Lighted	205	73.7	14.1	5.4	4.4	—	100
Darkness Highway Unlighted	1694	71.0	12.7	10.2	5.5	.4	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-37

Percent of Passenger Car Involvement in Accidents: Roadway Element By Weather Conditions

(1941-1952 Data)

ROADWAY ELEMENT	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Straight Level	2612	68.8	16.6	10.4	3.2	.7	100
Straight Up	1064	72.9	12.7	11.2	2.6	.5	100
Straight Down	1496	66.3	14.7	14.6	3.1	.8	100
Curved Level	310	60.0	29.3	6.8	3.9	—	100
Curved Up	441	63.2	18.6	16.1	1.4	.7	100
Curved Down	880	60.8	22.2	14.3	1.7	.8	100
Total	6984	67.0	16.9	12.2	2.8	.7	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-38

Percent of Truck Involvement in Accidents: Roadway Element By Weather Conditions

(1941-1952 Data)

ROADWAY ELEMENT	No.	PERCENT OF TOTAL Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet, Hail Freezing Rain	Total*
Straight Level	1296	74.1	10.7	9.6	4.6	.6	100
Straight Up	952	81.0	8.6	6.7	3.4	.3	100
Straight Down	803	67.8	14.3	11.8	5.2	.5	100
Curved Level	106	75.5	10.4	6.6	5.6	—	100
Curved Up	286	68.5	12.6	15.7	3.2	—	100
Curved Down	382	55.8	25.4	14.9	2.1	1.3	100
Total	3904	72.0	12.5	10.4	4.1	.5	100

**Since unknown weather conditions were eliminated from these tables, totals will not necessarily equal 100%.*

TABLE C-39

Percent of Passenger Car Involvement in Accidents: How Vehicle Was Involved By Roadway Conditions

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
Pedestrian	45	66.7	20.0	8.9	4.4	—	—	100
Rear End	2620	54.0	16.5	6.3	22.0	.8	.4	100
Stopping, Stopped, Parked	369	43.4	15.4	12.5	28.5	.2	—	100
Medial Strip	726	30.9	26.6	9.6	30.9	1.2	.8	100
Coll. W/Obj. Other than Vehicle	966	53.1	22.9	4.9	18.3	.6	.2	100
Overturning	943	58.9	17.4	4.1	18.7	.6	.3	100
Fire Only	64	90.6	6.3	—	3.1	—	—	100
Running Off Roadway	396	49.0	25.0	5.3	19.7	1.0	—	100
Sideswiping	571	57.6	14.5	7.0	20.0	.7	.2	100
Others	284	66.3	10.9	5.3	14.7	.3	2.5	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-40

Percent of Truck Involvement in Accidents: How Vehicle Was Involved By Roadway Conditions

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
Pedestrian	17	64.7	17.6	—	11.8	—	5.9	100
Rear End	1859	62.0	15.3	5.5	16.3	.6	.3	100
Stopping, Stopped, Parked	372	57.1	13.1	11.2	17.9	.7	—	100
Medial Strip	221	26.7	26.2	11.8	33.9	.9	.5	100
Coll. W/Obj. Other than Vehicle	284	64.8	17.5	3.5	13.4	.4	.4	100
Overturning	296	63.9	17.6	2.7	15.2	.3	.3	100
Fire Only	206	88.8	6.8	1.0	2.9	—	.5	100
Running Off Roadway	105	62.9	18.1	1.9	14.2	1.9	1.0	100
Sideswiping	356	56.5	16.0	10.0	16.3	.6	.6	100
Others	188	60.0	15.1	6.5	15.7	—	2.7	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-41

Percent of Passenger Car Involvement in Accidents: Day of Week By Roadway Conditions

(1941-1952 Data)

DAY OF WEEK	No.	PERCENT OF TOTAL						Total
		Dry	Wet	Snow	Icy	Slush	Unknown	
Sunday	1486	48.4	18.2	4.6	27.5	.7	.6	100
Monday	874	49.0	19.2	4.8	16.7	.1	.2	100
Tuesday	685	50.9	20.7	7.3	20.1	.8	.2	100
Wednesday	745	52.1	18.0	8.5	19.7	.9	.8	100
Thursday	773	53.6	16.5	7.1	21.2	.8	.8	100
Friday	993	52.0	18.9	6.2	21.8	.8	.3	100
Saturday	1428	53.5	18.3	7.6	19.3	.9	.4	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-42

Percent of Truck Involvement in Accidents: Day of Week By Roadway Conditions

(1941-1952 Data)

DAY OF WEEK	No.	PERCENT OF TOTAL						Total
		Dry	Wet	Snow	Icy	Slush	Unknown	
Sunday	508	53.7	14.4	6.3	24.8	.2	.6	100
Monday	476	59.9	20.8	4.8	13.7	—	.8	100
Tuesday	537	60.2	18.2	7.4	13.6	.4	.2	100
Wednesday	624	59.9	16.6	7.2	14.9	.7	.7	100
Thursday	611	63.4	13.9	5.2	16.5	1.0	—	100
Friday	619	63.1	14.5	4.4	16.5	1.0	.5	100
Saturday	529	63.9	12.3	7.9	14.7	.6	.6	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-43

Percent of Passenger Car Involvement in Accidents: Place of Occurrence By Roadway Conditions

(1941-1952 Data)

		PERCENT OF TOTAL						
PLACE	No.	Dry	Wet	Snow	Icy	Slush	Unknown	Total
Normal	5674	52.3	18.2	6.4	21.9	.8	.4	100
Interchange Area	631	55.9	16.2	5.5	21.9	.2	.3	100
Gas Station Area	209	51.7	19.1	13.4	15.3	—	.5	100
Tunnel Portal & Approach	230	47.8	23.5	6.5	19.6	2.2	.4	100
In Tunnel	149	65.1	28.9	1.3	4.7	—	—	100
Major & Minor Bridge	91	34.1	23.1	5.5	37.3	—	—	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-44

Percent of Truck Involvement in Accidents: Place of Occurrence By Roadway Conditions

(1941-1952 Data)

		PERCENT OF TOTAL						
PLACE	No.	Dry	Wet	Snow	Icy	Slush	Unknown	Total
Normal	3149	61.2	15.4	6.2	16.1	.7	.4	100
Interchange Area	308	64.0	12.7	4.5	18.5	—	.3	100
Gas Station Area	227	56.8	20.3	10.1	11.9	—	.9	100
Tunnel Portal & Approach	132	47.0	16.6	5.3	28.8	.8	1.5	100
In Tunnel	60	65.0	31.7	—	3.3	—	—	100
Major & Minor Bridge	28	57.1	14.3	3.6	25.0	—	—	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-45

Percent of Passenger Car Involvement in Accidents: Number of Vehicles Involved By Roadway Conditions

(1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
1 Vehicle	2494	55.3	21.3	4.2	18.1	.8	.3	100
2 Vehicles	3549	54.7	16.0	7.2	20.9	.6	.6	100
3 or More Vehicles	937	37.5	20.0	9.3	32.3	.9	—	100
Unknown	4	—	75.0	25.0	—	—	—	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-46

Percent of Truck Involvement in Accidents: Number of Vehicles Involved By Roadway Conditions

(1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
1 Vehicle	887	69.6	15.2	2.0	11.6	.6	1.0	100
2 Vehicles	2581	60.5	15.4	7.1	16.2	.5	.3	100
3 or More Vehicles	433	43.7	18.7	9.0	27.7	.9	—	100
Unknown	3	100.0	—	—	—	—	—	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-47

Percent of Passenger Car Involvement in Accidents: State of Registration By Roadway Conditions

(1941-1952 Data)

		PERCENT OF TOTAL						
STATE OF REGISTRATION	No.	Dry	Wet	Snow	Icy	Slush	Unknown	Total
In State	2823	54.6	18.9	6.0	19.2	.7	.6	100
Out of State	4094	51.1	18.2	6.7	22.9	.8	.3	100
Unknown	67	47.7	18.0	6.0	28.3	—	—	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-48

Percent of Truck Involvement in Accidents: State of Registration By Roadway Conditions

(1941-1952 Data)

		PERCENT OF TOTAL						
STATE OF REGISTRATION	No.	Dry	Wet	Snow	Icy	Slush	Unknown	Total
In State	1670	60.4	15.4	7.1	15.9	.7	.5	100
Out of State	2166	61.2	16.1	5.4	16.4	.5	.4	100
Unknown	68	52.9	10.3	8.8	26.5	—	1.5	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-49

Percent of Passenger Car Involvements in Accidents: Sex of Driver By Roadway Conditions

(1941-1952 Data)

		PERCENT OF TOTAL						
SEX OF DRIVER	No.	Dry	Wet	Snow	Icy	Slush	Unknown	Total
Female	1020	54.7	18.9	6.2	18.9	.8	.5	100
Male	5848	52.1	18.5	6.4	21.9	.7	.4	100
Unknown	116	54.3	14.7	8.6	21.6	—	.8	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-50

Percent of Passenger Car Involvement in Accidents: Age of Driver By Roadway Conditions

(1941-1952 Data)

AGE OF DRIVER	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
16-25	2209	53.0	19.1	5.4	21.6	.8	.1	100
26-35	1981	50.0	17.7	7.6	23.3	.9	.5	100
36-45	1221	53.2	17.9	7.0	20.7	.5	.7	100
46-55	827	56.1	19.0	5.4	18.1	1.1	.3	100
56-Over	544	55.1	21.0	5.5	17.4	.6	.4	100
Unknown	202	45.5	13.9	7.9	30.2	—	2.5	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-51

Percent of Truck Involvement in Accidents: Age of Driver By Roadway Conditions

(1941-1952 Data)

AGE OF DRIVER	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
16-25	846	64.7	15.3	3.0	16.2	.6	.2	100
26-35	1629	60.5	16.6	6.1	15.8	.5	.5	100
36-45	930	60.0	16.2	7.3	15.4	.4	.7	100
46-55	304	57.6	14.8	8.6	17.7	1.3	—	100
56-Over	66	59.1	12.1	6.1	22.7	—	—	100
Unknown	129	51.2	7.7	14.7	24.8	.8	.8	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-52

Percent of Passenger Car Involvement in Accidents: Estimated Initial Speed By Roadway Conditions

(1941-1952 Data)

ESTIMATED INITIAL SPEED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
0	1128	53.1	17.3	7.7	21.0	.4	.5	100
1-10	223	58.3	14.8	8.1	17.9	.4	.5	100
11-20	279	33.0	17.2	9.3	40.5	—	—	100
21-30	619	32.1	14.7	11.8	39.7	1.5	.2	100
31-40	1328	38.6	15.4	10.0	34.4	1.2	.4	100
41-50	1757	53.8	22.2	4.8	17.9	.9	.4	100
51-60	1134	69.1	21.1	2.2	6.4	.6	.6	100
61-70	473	78.0	18.4	—	3.2	—	.4	100
71-Over	43	83.7	11.6	—	4.7	—	—	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-53

Percent of Truck Involvement in Accidents: Estimated Initial Speed By Roadway Conditions

(1941-1952 Data)

ESTIMATED INITIAL SPEED	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
0	978	58.1	15.3	7.2	18.3	.7	.4	100
1-10	324	47.2	14.8	11.1	26.2	—	.7	100
11-20	494	53.6	11.9	11.5	21.9	.8	.2	100
21-30	553	57.3	14.5	6.5	20.6	.6	.5	100
31-40	904	63.7	19.2	3.7	12.4	.6	.4	100
41-50	581	74.9	16.4	1.5	6.2	.5	.5	100
51-60	59	83.1	10.1	—	5.1	—	1.7	100
61-Over	11	70.0	20.0	—	10.0	—	—	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-54

Percent of Passenger Car Involvement in Accidents: Roadway Element By Roadway Conditions

(1941-1952 Data)

ROADWAY ELEMENT	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
Straight Level	2612	56.6	19.2	6.0	17.2	.8	.2	100
Straight Up	1064	58.7	14.5	7.1	19.0	.5	.2	100
Straight Down	1496	50.0	17.1	7.2	25.0	.4	.3	100
Curved Level	310	49.7	28.1	2.9	18.7	.6	—	100
Curved Up	441	48.1	16.1	6.3	29.0	.5	—	100
Curved Down	880	42.8	21.5	6.1	27.9	1.7	—	100
Others	181	42.0	18.8	7.7	22.1	.6	8.8	100
Total	6984	52.5	18.5	6.4	21.4	.8	.4	100

TABLE C-55

Percent of Truck Involvement in Accidents: Roadway Element By Roadway Conditions

(1941-1952 Data)

ROADWAY ELEMENT	No.	PERCENT OF TOTAL						
		Dry	Wet	Snow	Icy	Slush	Unknown	Total
Straight Level	1296	62.0	16.6	6.6	13.9	.6	.3	100
Straight Up	952	71.8	14.5	3.3	9.8	.4	.2	100
Straight Down	803	57.3	14.6	8.2	18.9	.7	.3	100
Curved Level	106	66.0	15.1	4.7	12.3	—	1.9	100
Curved Up	286	55.9	16.4	6.7	21.0	—	—	100
Curved Down	382	40.3	19.9	7.3	31.2	1.0	.3	100
Others	79	49.4	6.3	7.6	26.6	—	10.1	100
Total	3904	60.7	15.7	6.2	16.3	.6	.5	100

TABLE C-56

Percent of Passenger Car Involvement in Accidents: How Vehicle Was Involved By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
HOW VEHICLE WAS INVOLVED	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
Pedestrian	45	37.8	6.7	31.1	2.2	4.4	13.4	4.4	100
Rear End	2620	41.3	18.4	20.1	3.5	6.0	7.7	3.0	100
Stopping, Stopped, Parked	369	44.4	14.6	22.5	2.4	4.9	9.8	1.4	100
Medial Strip	726	32.8	15.7	17.9	5.2	9.5	16.0	2.9	100
Coll. W/Obj. Other Than Vehicle	966	34.2	12.4	22.6	5.9	5.9	16.0	3.0	100
Overturning	943	31.1	9.5	24.9	6.7	6.5	19.5	1.8	100
Fire Only	64	50.0	14.1	20.3	—	3.1	10.9	1.6	100
Running Off Roadway	396	32.8	12.1	22.5	4.3	8.1	18.4	1.8	100
Sideswiping	571	37.8	18.4	22.8	4.0	4.7	10.7	1.6	100
Others	284	39.1	14.1	20.1	3.5	5.6	13.4	4.2	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-57

Percent of Truck Involvement in Accidents: How Vehicle Was Involved By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
HOW VEHICLE WAS INVOLVED	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
Pedestrian	17	47.1	11.8	23.4	—	5.9	5.9	5.9	100
Rear End	1859	32.4	21.4	17.9	2.1	7.7	6.1	2.4	100
Stopping, Stopped, Parked	372	39.5	22.8	23.0	3.0	3.0	6.5	2.2	100
Medial Strip	221	23.5	19.9	19.9	2.8	15.8	15.8	2.3	100
Coll. W/Obj. Other Than Vehicle	284	35.2	13.7	25.7	4.6	6.7	13.4	.7	100
Overturning	296	26.4	8.4	26.7	5.1	7.4	24.7	1.3	100
Fire Only	206	52.9	20.4	15.0	1.9	5.9	2.9	1.0	100
Running Off Roadway	105	27.6	10.5	29.5	3.8	6.7	19.0	2.9	100
Sideswiping	356	30.9	25.3	22.2	1.7	6.2	12.9	.8	100
Others	188	32.4	16.5	22.9	4.3	6.9	13.8	3.2	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

TABLE C-58

Percent of Passenger Car Involvement in Accidents: Day of Week By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
DAY OF WEEK	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
Sunday	1486	36.9	13.5	20.5	4.5	6.1	14.7	3.8	100
Monday	874	38.3	18.6	19.7	4.6	6.1	10.5	2.2	100
Tuesday	685	37.3	16.6	22.2	4.4	6.1	11.8	1.6	100
Wednesday	745	35.4	17.2	21.2	4.6	6.3	11.8	3.5	100
Thursday	773	38.8	16.9	21.0	3.0	6.1	11.6	2.6	100
Friday	993	36.1	12.1	24.6	4.2	8.3	12.7	2.0	100
Saturday	1428	38.6	14.6	21.1	5.2	5.5	13.0	2.0	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-59

Percent of Truck Involvement in Accidents: Day of Week By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
DAY OF WEEK	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
Sunday	508	28.0	24.4	21.5	3.3	9.3	10.4	3.1	100
Monday	476	34.0	27.7	18.5	2.1	7.4	8.2	2.1	100
Tuesday	537	35.4	22.2	24.6	2.8	5.0	8.7	1.3	100
Wednesday	624	33.3	25.8	17.9	2.7	7.2	10.1	3.0	100
Thursday	611	32.0	24.5	20.4	1.5	8.5	11.8	1.3	100
Friday	619	33.1	23.2	21.2	3.7	7.3	10.5	1.0	100
Saturday	529	36.4	23.1	20.2	2.6	6.6	8.5	2.6	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

TABLE C-60

Percent of Passenger Car Involvement in Accidents: Number of Vehicles Involved By Roadway Element (1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	No.	PERCENT OF TOTAL Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
1 Vehicle	2494	33.2	10.9	23.3	6.1	6.3	17.8	2.4	100
2 Vehicles	3549	39.4	19.4	18.7	4.0	6.6	9.1	2.8	100
3 or More Vehicles	937	40.8	11.4	26.8	1.8	5.2	12.0	2.0	100
Unknown	4	50.0	—	—	—	—	—	50.0	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-61

Percent of Truck Involvement in Accidents: Number of Vehicles Involved By Roadway Element (1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	No.	PERCENT OF TOTAL Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
1 Vehicle	887	35.1	12.7	24.8	3.8	7.3	14.9	1.4	100
2 Vehicles	2581	33.2	29.6	17.9	2.5	7.2	7.4	2.2	100
3 or More Vehicles	433	30.0	16.6	27.8	1.6	8.1	13.6	2.3	100
Unknown	3	33.3	66.7	—	—	—	—	—	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

TABLE C-62

Percent of Passenger Car Involvement in Accidents: State of Registration By Roadway Element (1941-1952 Data)

STATE OF REGISTRATION	No.	PERCENT OF TOTAL Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
In State	2823	38.9	15.8	20.4	4.2	6.2	11.6	2.9	100
Out of State	4094	36.4	14.9	22.0	4.6	6.4	13.3	2.4	100
Unknown	67	35.8	13.4	28.4	6.0	3.0	13.4	—	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-63

Percent of Truck Involvement in Accidents: State of Registration By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
STATE OF REGISTRATION	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
In State	1670	33.5	24.4	19.2	3.0	7.4	10.2	2.3	100
Out of State	2166	32.8	24.8	21.7	2.5	7.2	9.4	1.6	100
Unknown	68	39.7	11.8	17.6	1.5	8.8	10.3	10.3	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

TABLE C-64

Percent of Passenger Car Involvement in Accidents: Sex of Driver By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
SEX OF DRIVER	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
Female	1020	38.0	12.8	22.6	4.4	5.5	13.9	2.8	100
Male	5848	37.3	15.6	21.2	4.4	6.5	12.5	2.5	100
Unknown	116	34.5	17.2	23.3	6.0	5.2	6.9	6.9	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-65

Percent of Passenger Car Involvement in Accidents: Age of Driver By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
AGE OF DRIVER	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
16-25	2209	37.6	16.2	19.4	5.0	6.6	13.1	2.1	100
26-35	1981	37.6	15.1	22.1	4.3	6.1	12.0	2.8	100
36-45	1221	38.9	15.2	20.8	4.1	6.0	12.2	2.8	100
46-55	827	35.9	13.9	23.2	4.1	6.9	13.4	2.6	100
56-Over	544	34.4	14.7	25.7	3.7	5.5	13.6	2.4	100
Unknown	202	38.1	12.9	21.8	5.0	7.4	9.4	5.4	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-66

Percent of Truck Involvement in Accidents: Age of Driver By Roadway Element

(1941-1952 Data)

		PERCENT OF TOTAL							
AGE OF DRIVER	No.	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
16-25	846	35.3	23.5	20.4	2.8	8.1	8.5	1.4	100
26-35	1629	32.8	26.8	20.0	2.7	6.9	9.1	1.7	100
36-45	930	32.3	24.4	21.1	3.2	7.2	9.9	1.9	100
46-55	304	34.3	18.4	20.7	1.6	7.9	14.5	2.6	100
56-Over	66	25.8	13.6	28.8	1.5	6.1	19.7	4.5	100
Unknown	129	32.5	18.6	20.9	1.6	8.5	10.1	7.8	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

TABLE C-67

Percent of Passenger Car Involvement in Accidents: Estimated Initial Speed By Roadway Element

(1941-1952 Data)

ESTIMATED INITIAL SPEED	No.	PERCENT OF TOTAL							
		Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
0	1128	43.8	14.9	21.8	3.1	5.1	9.1	2.2	100
1-10	223	45.8	9.4	21.5	3.1	6.3	9.0	4.9	100
11-20	279	39.4	14.3	25.1	3.2	5.4	9.7	2.9	100
21-30	619	38.4	14.1	24.1	2.7	5.7	12.9	2.1	100
31-40	1328	38.4	15.0	21.2	2.9	7.1	12.3	3.1	100
41-50	1757	34.6	15.5	22.0	5.4	6.5	13.6	2.4	100
51-60	1134	34.9	17.1	17.9	6.6	5.8	14.6	3.1	100
61-70	473	29.3	15.9	22.2	6.8	9.1	15.4	1.3	100
71-Over	43	37.1	18.6	16.3	4.7	4.7	18.6	—	100
Total	6984	37.4	15.2	21.4	4.5	6.3	12.6	2.6	100

TABLE C-68

Percent of Truck Involvement in Accidents: Estimated Initial Speed By Roadway Element

(1941-1952 Data)

ESTIMATED INITIAL SPEED	No.	PERCENT OF TOTAL							
		Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Others	Total
0	978	35.4	21.5	21.7	2.2	7.0	9.2	3.0	100
1-10	324	37.1	20.1	18.8	3.4	8.3	11.1	1.2	100
11-20	494	23.1	41.1	13.0	2.4	11.3	6.5	2.6	100
21-30	553	32.5	27.3	20.6	.9	7.2	10.1	1.4	100
31-40	904	34.1	22.2	21.5	3.4	6.3	10.8	1.7	100
41-50	581	34.6	18.6	23.8	3.8	6.5	11.1	1.5	100
51-60	59	40.7	22.0	27.1	3.4	—	6.8	—	100
61-Over	11	27.3	9.1	36.3	9.1	—	9.1	9.1	100
Total	3904	33.2	24.4	20.6	2.7	7.3	9.8	2.0	100

II

ENVIRONMENTAL CONTINGENCY TABLES

Light Conditions

Weather Conditions

Roadway Conditions

Roadway Element

TABLE C-69

Comparison of Light Conditions According To Frequency By How Passenger Car Was Involved

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	LIGHT CONDITIONS Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Pedestrian	25	19	1	0	45
	(26.96)*	(13.88)	(1.75)	(2.43)	
Rear End	1453	855	158	125	2591
	(1551.51)	(798.74)	(100.91)	(139.88)	
Stopped, Parked,	188	133	23	24	368
Stopping	(220.36)	(113.45)	(14.33)	(19.87)	
Medial Strip	484	186	16	34	720
	(431.13)	(221.95)	(28.04)	(38.87)	
Collision with Object	559	318	32	51	960
Other Than Vehicle	(574.84)	(295.94)	(37.39)	(51.83)	
Overturning	628	248	8	55	939
	(562.26)	(289.46)	(36.57)	(50.69)	
Fire Only	42	16	0	5	63
	(37.71)	(19.41)	(2.45)	(3.40)	
Running Off Roadway .	239	118	4	34	395
	(236.53)	(121.77)	(15.39)	(21.32)	
Sideswiping	364	157	17	31	569
	(340.70)	(175.10)	(22.16)	(30.72)	
Total	3982	2050	259	359	6650

Chi-Square = 145.51
df = 24
Probability = .001 (Less than 1 time in 1000 would these deviations occur by chance alone)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-70

Comparison of Light Conditions According To Frequency By How Truck Was Involved

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	LIGHT CONDITIONS Daylight	 Darkness Highway Unlighted	 Darkness Highway Lighted	 Dusk & Dawn	 Total
Rear End	796	862	94	89	1841
	(828.93)*	(814.38)	(98.35)	(99.35)	
Stopped, Parked, Stopping	127	164	48	32	371
	(167.05)	(164.11)	(19.82)	(20.02)	
Medial Strip	130	77	4	8	219
	(98.61)	(96.88)	(11.70)	(11.82)	
Collision with Object Other Than Vehicle	122	125	20	16	283
	(127.42)	(125.19)	(15.12)	(15.27)	
Overturning	142	120	14	18	294
	(132.38)	(130.05)	(15.71)	(15.87)	
Fire Only	78	112	6	8	204
	(91.85)	(90.24)	(10.90)	(11.01)	
Running Off Roadway.	60	36	2	5	103
	(46.38)	(45.56)	(5.50)	(5.56)	
Sideswiping	197	127	8	22	354
	(159.39)	(156.59)	(18.91)	(19.10)	
Total	1652	1623	196	198	3669

Chi-Square = 126.21
df = 21
Probability = .001 (Less than 1 time in 1000 would these deviations occur by chance alone)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-71

Comparison of Light Conditions According To Passenger Car Involvement By Day of Week

(1941-1952 Data)

	LIGHT CONDITIONS				
DAY OF WEEK	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Sunday	820	511	59	81	1471
	(884.00)*	(450.49)	(56.68)	(79.82)	
Monday	517	261	27	65	870
	(522.83)	(266.44)	(33.52)	(47.21)	
Tuesday	438	177	24	41	680
	(408.65)	(208.25)	(26.20)	(36.90)	
Wednesday	450	220	26	38	734
	(441.10)	(224.79)	(28.28)	(39.83)	
Thursday	504	205	27	34	770
	(462.73)	(235.81)	(29.67)	(41.78)	
Friday	563	347	35	45	990
	(594.94)	(303.19)	(38.15)	(53.72)	
Saturday	872	401	69	72	1414
	(849.75)	(433.04)	(54.49)	(76.73)	
Total	4164	2122	267	376	6929

Chi-Square = 55.23

df = 18

Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-72

Comparison of Light Conditions According To Truck Involvement By Day of Week

(1941-1952 Data)

	LIGHT CONDITIONS				
DAY OF WEEK	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Sunday	240	218	22	23	503
	(229.35)*	(220.12)	(26.64)	(26.90)	
Monday	194	232	28	20	474
	(216.12)	(207.43)	(25.10)	(25.35)	
Tuesday	262	221	26	26	535
	(243.94)	(234.12)	(28.33)	(28.61)	
Wednesday	267	267	39	43	616
	(280.87)	(269.57)	(32.62)	(32.94)	
Thursday	286	238	50	35	609
	(277.68)	(266.51)	(32.25)	(32.57)	
Friday	275	287	23	31	616
	(280.87)	(269.57)	(32.62)	(32.94)	
Saturday	241	231	17	29	518
	(236.18)	(226.68)	(27.43)	(27.70)	
Total	1765	1694	205	207	3871

Chi-Square = 37.72
df = 18
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-73

Comparison of Light Conditions According To Passenger Car Involvement By Place of Occurrence

(1941-1952 Data)

	LIGHT CONDITIONS			
PLACE OF OCCURRENCE (Main Line)	Daylight	Darkness	Dusk & Dawn	Total
Normal	3404	1925	313	5642
	(3390.57)*	(1945.26)	(306.16)	
Interchange Area	371	228	29	628
	(377.40)	(216.52)	(34.08)	
Gas Station Area	145	58	5	208
	(125.00)	(71.72)	(11.29)	
Tunnel Approach and Portal	127	77	19	223
	(134.01)	(76.89)	(12.10)	
In Tunnel	72	60	5	137
	(82.33)	(47.24)	(7.43)	
Major and Minor Bridges	45	41	5	91
	(54.69)	(31.37)	(4.94)	
Total	4164	2389	376	6929

Chi-Square = 25.73
df = 10
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-74

Comparison of Light Conditions According To Truck Involvement Frequency By Place of Occurrence

(1941-1952 Data)

PLACE OF OCCURRENCE (Main Line)	LIGHT CONDITIONS Daylight	 Darkness	 Dusk & Dawn	 Total
Normal	1425 (1421.30)*	1464 (1468.01)	167 (166.69)	3056
Interchange Area	135 (142.31)	157 (146.99)	14 (16.69)	306
Gas Station Area	106 (104.65)	110 (108.09)	9 (12.27)	225
Tunnel Approach and Portal	60 (58.60)	53 (60.52)	13 (6.87)	126
In Tunnel	28 (25.12)	22 (25.94)	4 (2.95)	54
Major and Minor Bridges	11 (13.03)	17 (13.45)	0 (1.53)	28
Total	1765	1823	207	3795

Chi-Square = 12.96
df = 10
Probability = .30 (30 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-75

Comparison of Light Conditions According To Passenger Car Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

		LIGHT CONDITIONS			
NUMBER OF VEHICLES	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
1 Vehicle	1537	740	49	154	2480
	(1490.43)*	(759.72)	(95.23)	(134.61)	
2 Vehicles	2073	1134	136	178	3521
	(2116.05)	(1078.62)	(135.21)	(191.12)	
3 or more Vehicles	553	248	81	44	926
	(556.51)	(283.67)	(35.56)	(50.26)	
Total	4163	2122	266	376	6927

Chi-Square = 95.18
df = 6
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-76

Comparison of Light Conditions According To Truck Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

		LIGHT CONDITIONS			
NUMBER OF VEHICLES	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
1 Vehicle	386	407	41	43	877
	(400.18)	(383.40)	(46.48)	(46.93)	
2 Vehicles	1176	1108	136	142	2562
	(1169.07)	(1120.05)	(135.78)	(137.11)	
3 or more Vehicles	203	176	28	22	429
	(195.76)	(187.55)	(22.74)	(22.96)	
Total	1765	1691	205	207	3868

Chi-Square = 5.51
df = 6
Probability = .5 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-77

Comparison of Light Conditions According To Passenger Car Involvement Frequency By State of Registration

(1941-1952 Data)

	LIGHT CONDITIONS				
STATE OF REGISTRATION	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
In State	1588	932	114	167	2801
	(1683.78)*	(855.97)	(108.17)	(153.07)	
Out of State	2537	1165	151	208	4061
	(2441.22)	(1241.03)	(156.83)	(221.93)	
Total	4125	2097	265	375	6862

Chi-Square = 23.29
df = 3
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-78

Comparison of Light Conditions According To Truck Involvement Frequency By State of Registration

(1941-1952 Data)

	LIGHT CONDITIONS				
STATE OF REGISTRATION	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
In State	743	742	80	89	1654
	(752.41)*	(726.75)	(86.98)	(87.85)	
Out of State	987	929	120	113	2149
	(977.59)	(944.25)	(113.02)	(114.15)	
Total	1730	1671	200	202	3803

Chi-Square = 1.79
df = 3
Probability = .70 (70 times in 100 these deviations would occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-79

Comparison of Light Conditions According To Passenger Car Involvement Frequency By Sex of Driver

(1941-1952 Data)

		LIGHT CONDITIONS			
SEX OF DRIVER	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Female	713	219	25	55	1012
	(608.93)*	(308.48)	(39.21)	(55.40)	
Male	3387	1858	239	318	5802
	(3491.07)	(1768.52)	(224.79)	(317.60)	
Total	4100	2077	264	373	6814

Chi-Square = 57.42
df = 3
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-80

Comparison of Light Conditions According To Passenger Car Involvement Frequency By Age of Driver

(1941-1952 Data)

		LIGHT CONDITIONS			
AGE OF DRIVER	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
16-25	1173	803	85	129	2190
	(1321.22)*	(664.03)	(84.31)	(120.44)	
26-35	1153	620	81	117	1971
	(1189.10)	(597.63)	(75.88)	(108.39)	
36-45	761	353	35	61	1210
	(729.99)	(366.88)	(46.57)	(66.54)	
46-55	557	181	38	39	815
	(491.69)	(247.12)	(31.37)	(44.82)	
56-over	415	83	20	24	542
	(326.99)	(164.34)	(20.86)	(29.81)	
Total	4059	2040	259	370	6728

Chi-Square = 148.10
df = 12
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-81

Comparison of Light Conditions According To Truck Involvement Frequency by Age of Driver

(1941-1952 Data)

	LIGHT CONDITIONS				
AGE OF DRIVER	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
16-25	392 (386.58)*	353 (368.11)	46 (43.70)	52 (44.61)	843
26-35	686 (739.23)	758 (703.90)	93 (83.57)	75 (85.30)	1612
36-45	441 (421.43)	386 (401.30)	43 (47.64)	49 (48.63)	919
46-55	157 (138.95)	119 (132.31)	11 (15.71)	16 (16.03)	303
56-over	40 (29.81)	18 (28.38)	1 (3.37)	6 (3.44)	65
Total	1716	1634	194	198	3742

Chi-Square = 30.23
df = 12
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-82

Comparison of Light Conditions According To Passenger Car Involvement Frequency By Estimated Initial Speed

(1941-1952 Data)

	LIGHT CONDITIONS				
ESTIMATED INITIAL SPEED	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
0	587 (668.26)*	377 (340.55)	91 (42.85)	57 (60.34)	1112
1-10	136 (132.21)	61 (67.38)	12 (8.48)	11 (11.94)	220
11-20	175 (166.46)	74 (84.83)	16 (10.67)	12 (15.03)	277
21-30	354 (367.18)	184 (187.12)	38 (23.54)	35 (33.16)	611
31-40	768 (793.86)	418 (404.56)	64 (50.90)	71 (71.68)	1321
41-50	1074 (1049.26)	547 (534.71)	28 (67.28)	97 (94.75)	1746
51-60	726 (677.27)	328 (345.14)	13 (43.43)	60 (61.16)	1127
61-70	312 (283.65)	123 (144.55)	4 (18.19)	33 (25.61)	472
71-over	32 (25.84)	10 (13.17)	1 (1.66)	0 (2.33)	43
Total	4164	2122	267	376	6929

Chi-Square = 163.21
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-83

Comparison of Light Conditions According To Truck Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

	LIGHT CONDITIONS				
ESTIMATED INITIAL SPEED	**Daylight**	**Darkness Highway Unlighted**	**Darkness Highway Lighted**	**Dusk & Dawn**	**Total**
0	407 (443.50)*	416 (425.91)	87 (51.54)	63 (52.04)	973
1-10	160 (144.95)	113 (139.20)	30 (16.84)	15 (17.01)	318
11-20	239 (222.90)	217 (214.05)	14 (25.90)	19 (26.16)	489
21-30	264 (248.88)	221 (239.01)	36 (28.92)	25 (29.21)	546
31-40	382 (408.86)	434 (392.64)	30 (47.51)	51 (47.98)	897
41-50	278 (263.45)	262 (253.00)	8 (30.62)	30 (30.92)	578
51-over	34 (31.45)	31 (30.20)	0 (3.66)	4 (3.69)	69
Total	1764	1694	205	207	3870

Chi-Square = 94.74
df = 18
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-84

Comparison of Light Conditions According To Passenger Car Involvement By Roadway Conditions

(1941-1952 Data)

ROADWAY CONDITIONS	LIGHT CONDITIONS Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Dry	2211 (2198.14)*	1079 (1118.62)	163 (140.55)	203 (198.68)	3656
Wet	790 (767.77)	370 (390.71)	51 (49.09)	66 (69.39)	1277
Snow	284 (267.57)	126 (136.17)	11 (17.11)	24 (24.18)	445
Ice	832 (895.23)	536 (455.58)	38 (57.24)	83 (80.92)	1489
Slush	43 (31.28)	6 (15.92)	3 (2.00)	0 (2.83)	52
Total	4160	2117	266	376	6919

Chi-Square = 50.18
df = 12
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-85

Comparison of Light Conditions According To Truck Involvement by Roadway Conditions

(1941-1952 Data)

	LIGHT CONDITIONS				
ROADWAY CONDITIONS	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Dry	1052 (1078.89)*	1062 (1034.21)	136 (124.23)	114 (126.68)	2364
Wet	257 (277.02)	274 (265.55)	36 (31.90)	40 (32.53)	607
Snow	148 (109.99)	72 (105.43)	6 (12.66)	15 (12.91)	241
Ice	291 (287.06)	275 (275.18)	25 (33.05)	38 (33.71)	629
Slush	15 (10.04)	7 (9.62)	0 (1.16)	0 (1.18)	22
Total	1763	1690	203	207	3863

Chi-Square = 43.40
df = 12
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-86

Comparison of Light Conditions According To Passenger Car Involvement Frequency By Roadway Element

(1941-1952 Data)

	LIGHT CONDITIONS				
ROADWAY ELEMENT	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Straight Level	590	518	94	82	1284
	(587.75)*	(560.71)	(68.27)	(67.26)	
Straight Up	363	514	22	49	948
	(433.95)	(413.99)	(50.41)	(49.66)	
Straight Down	402	303	61	33	799
	(365.75)	(348.92)	(42.48)	(41.85)	
Curved Level	53	42	6	2	103
	(47.14)	(44.98)	(5.48)	(5.39)	
Curved Up	144	120	4	16	284
	(130.00)	(124.03)	(15.10)	(14.88)	
Curved Down	187	162	15	17	381
	(174.40)	(166.38)	(20.26)	(19.96)	
Total	1739	1659	202	199	3799

Chi-Square = 103.37
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-87

Comparison of Light Conditions According To Truck Involvement Frequency by Roadway Element

(1941-1952 Data)

ROADWAY ELEMENT	LIGHT CONDITIONS Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Straight Level	1596 (1555.98)*	718 (793.31)	144 (99.98)	133 (141.73)	2591
Straight Up	608 (637.77)	369 (325.16)	30 (40.98)	55 (58.09)	1062
Straight Down	911 (891.19)	426 (454.37)	61 (57.26)	86 (81.18)	1484
Curved Level	185 (186.17)	101 (94.92)	8 (11.96)	16 (16.96)	310
Curved Up	253 (264.23)	160 (134.72)	5 (16.98)	22 (24.07)	440
Curved Down	509 (526.67)	297 (268.52)	13 (33.84)	58 (47.97)	877
Total	4062	2071	261	370	6764

Chi-Square = 75.40
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-88

Comparison of Weather Conditions According To Passenger Car Involvement Frequency By How Vehicle Was Involved

(1941-1952 Data)

	WEATHER CONDITIONS				
HOW VEHICLE WAS INVOLVED	Clear Cloudy	Raining	Misty Foggy	Sleet—Snow Freezing Rain Hail	Total
Pedestrian	32	5	3	5	45
	(30.11)*	(7.76)	(1.24)	(5.86)	
Rear End	1745	374	111	337	2607
	(1745.17)	(450.06)	(71.89)	(339.89)	
Stopped, Stopping, Parked	248	61	7	53	369
	(247.03)	(63.71)	(10.18)	(48.11)	
Medial Strip	377	185	12	144	718
	(480.65)	(123.96)	(19.80)	(93.61)	
Collision W/Obj. Other Than Vehicle	665	190	15	95	965
	(645.97)	(166.59)	(26.61)	(125.81)	
Overturning	674	160	17	91	942
	(630.61)	(162.63)	(25.98)	(122.82)	
Fire Only	60	1	2	0	63
	(42.17)	(10.87)	(1.74)	(8.21)	
Running Off Roadway	253	102	5	36	396
	(265.07)	(68.36)	(10.92)	(51.63)	
Sideswiping	413	74	12	69	568
	(380.23)	(98.06)	(15.66)	(74.05)	
Total	4467	1152	184	870	6673

Chi-Square = 216.68
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-89

Comparison of Weather Conditions According To Truck Involvement Frequency By How Vehicle Was Involved

(1941-1952 Data)

	WEATHER CONDITIONS				
HOW VEHICLE WAS INVOLVED	Clear Cloudy	Raining	Misty Foggy	Sleet—Snow Freezing Rain Hail	Total
Pedestrian	12 (11.06)*	3 (1.91)	0 (.64)	1 (2.39)	16
Rear End	1345 (1278.06)	222 (220.26)	94 (74.06)	188 (276.63)	1849
Stopped, Stopping, Parked.	266 (290.31)	49 (50.03)	13 (16.82)	92 (62.84)	420
Medial Strip	105 (180.41)	42 (31.09)	17 (10.45)	97 (39.05)	261
Collision W/Obj. Other Than Vehicle. . . .	218 (220.50)	36 (38.00)	9 (12.78)	56 (47.73)	319
Overturning	208 (235.70)	49 (40.62)	9 (13.66)	75 (51.02)	341
Fire Only	192 (141.01)	5 (24.30)	3 (8.17)	4 (30.52)	204
Running Off Roadway.	79 (72.58)	18 (12.51)	1 (4.21)	7 (15.71)	105
Sideswiping	250 (245.38)	37 (42.29)	9 (14.22)	59 (53.11)	355
Total	2675	461	155	579	3870

Chi-Square = 268.84
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-90

Comparison of Weather Conditions According To Passenger Car Involvement Frequency By Day of Week

(1941-1952 Data)

	WEATHER CONDITIONS					
DAY OF WEEK	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
Sunday	956 (994.41)*	279 (251.42)	210 (181.50)	23 (41.02)	8 (7.65)	1476
Monday	622 (587.48)	146 (148.54)	71 (107.23)	25 (24.23)	8 (4.52)	872
Tuesday	454 (459.48)	128 (116.17)	79 (83.87)	14 (18.95)	7 (3.53)	682
Wednesday	489 (497.88)	101 (125.88)	121 (90.87)	26 (20.54)	2 (3.83)	739
Thursday	545 (520.79)	124 (131.67)	88 (95.06)	14 (21.48)	2 (4.00)	773
Friday	649 (665.64)	175 (168.30)	122 (121.49)	33 (27.46)	9 (5.12)	988
Saturday	964 (960.05)	230 (242.73)	163 (175.23)	58 (39.60)	10 (7.38)	1425
Total	4679	1183	854	193	36	6945

Chi-Square = 79.04
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-91

Comparison of Weather Conditions According To Truck Involvement Frequency By Day of Week

(1941-1952 Data)

DAY OF WEEK	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
Sunday	137 (215.46)*	84 (40.27)	65 (33.34)	17 (13.29)	1 (1.65)	304
Monday	328 (335.23)	76 (62.66)	42 (51.87)	24 (20.67)	3 (2.57)	473
Tuesday	390 (379.88)	64 (71.00)	59 (58.78)	23 (23.42)	0 (2.91)	536
Wednesday	438 (439.42)	75 (82.13)	63 (67.99)	39 (27.10)	5 (3.37)	620
Thursday	468 (433.04)	67 (80.94)	57 (67.00)	19 (26.70)	0 (3.32)	611
Friday	448 (433.75)	73 (81.07)	60 (67.11)	23 (26.75)	8 (3.32)	612
Saturday	402 (374.21)	49 (69.94)	58 (57.90)	16 (23.07)	3 (2.87)	528
Total	2611	488	404	161	20	3684

Chi-Square = 155.69
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-92

Comparison of Weather Conditions According To Passenger Car Involvement Frequency By Place Main Line

(1941-1952 Data)

PLACE MAIN LINE	Clear Cloudy	Raining	Snow, Sleet Freezing Rain Hail	Misty Foggy	Total
			WEATHER CONDITIONS		
Normal	3790 (3804.42)*	955 (961.88)	754 (731.78)	156 (156.92)	5655
Interchange Area	438 (423.16)	99 (106.99)	72 (81.39)	20 (17.45)	629
Gas Station Area	158 (140.61)	37 (35.55)	13 (27.05)	1 (5.80)	209
Tunnel Approach and Portal	149 (152.72)	42 (38.61)	30 (29.37)	6 (6.30)	227
Major and Minor Bridges	48 (61.22)	21 (15.48)	17 (11.78)	5 (2.53)	91
In Tunnel	96 (96.88)	29 (24.49)	14 (18.63)	5 (4.00)	144
Total	4679	1183	900	193	6955

Chi-Square = 29.04
df = 15
Probability = .02 (less than 2 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-93

Comparison of Weather Conditions According To Truck Involvement Frequency By Place Main Line

(1941-1952 Data)

PLACE MAIN LINE	WEATHER CONDITIONS Clear Cloudy	Raining	Snow, Sleet Freezing Rain Hail	Misty Foggy	Total
Normal	2264 (2268.92)*	382 (393.89)	357 (342.23)	132 (129.95)	3135
Interchange Area	232 (222.91)	35 (38.70)	24 (33.62)	17 (12.77)	308
Gas Station Area	169 (164.29)	33 (28.52)	21 (24.78)	4 (9.41)	227
Tunnel Approach and Portal	86 (92.64)	18 (16.08)	18 (13.97)	6 (5.31)	128
In Tunnel	42 (41.98)	14 (7.29)	2 (6.33)	0 (2.40)	58
Major and Minor Bridge	18 (20.26)	6 (3.52)	2 (3.06)	2 (1.16)	28
Total	2811	488	424	161	3884

Chi-Square = 26.91
df = 15
Probability = .05 (less than 5 times in 100 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-94

Comparison of Weather Conditions According to Passenger Car Involvement Frequency By Number of Vehicles Involved

(1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
1 Vehicle	1712	487	232	43	15	2489
	(1674.62)*	(423.67)	(305.13)	(69.12)	(16.47)	
2 Vehicles	2449	487	460	114	19	3529
	(2374.33)	(600.69)	(432.62)	(98.00)	(23.36)	
3 or More Vehicles.	515	209	160	36	12	932
	(627.05)	(158.64)	(114.25)	(25.88)	(6.17)	
Total	4676	1183	852	193	46	6950

Chi-Square = 130.65
df = 8
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-95

Comparison of Weather Conditions According to Truck Involvement Frequency By Number of Vehicles Involved

(1941-1952 Data)

NUMBER OF VEHICLES INVOLVED	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
1 Vehicle	691	107	59	21	2	880
	(636.70)*	(110.65)	(91.61)	(36.51)	(4.53)	
2 Vehicles	1880	287	293	94	17	2571
	(1860.18)	(323.28)	(267.63)	(106.66)	(13.25)	
3 or More Vehicles.	237	94	52	46	1	430
	(311.12)	(54.07)	(44.76)	(17.84)	(2.22)	
Total	2808	488	404	161	20	3881

Chi-Square = 127.05
df = 8
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-96

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by State of Registration

(1941-1952 Data)

STATE OF REGISTRATION	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
In State	1888 (1887.78)*	496 (479.07)	325 (344.23)	83 (76.18)	14 (18.74)	2806
Out of State......	2746 (2746.22)	680 (696.93)	520 (500.77)	104 (110.82)	32 (27.26)	4082
Total	4634	1176	845	187	46	6888

Chi-Square = 5.88
df = 4
Probability = .30 (30 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-97

Comparison of Weather Conditions According to Truck Involvement Frequency by State of Registration

(1941-1952 Data)

STATE OF REGISTRATION	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
In State	1204 (1201.73)*	214 (208.69)	175 (171.74)	55 (69.13)	12 (8.70)	1660
Out of State......	1560 (1562.27)	266 (271.31)	220 (223.26)	104 (89.87)	8 (11.30)	2158
Total	2764	480	395	159	20	3818

Chi-Square = 7.68
df = 4
Probability = .20 (20 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-98

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by Sex of Driver

(1941-1952 Data)

	WEATHER CONDITIONS					
SEX OF DRIVER	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
Female	693	173	116	27	4	1013
	(680.52)*	(173.43)	(124.26)	(28.29)	(6.52)	
Male	3902	998	723	164	40	5827
	(3914.48)	(997.57)	(714.74)	(162.71)	(37.48)	
Total	4595	1171	839	191	44	6840

Chi-Square = 2.13
df = 4
Probability = .80 (80 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-99

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by Age of Driver

(1941-1952 Data)

	WEATHER CONDITIONS					
AGE OF DRIVER	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
16-25	1497	371	268	57	12	2205
	(1485.45)*	(376.91)	(266.94)	(61.68)	(14.03)	
26-35	1297	347	253	61	15	1973
	(1329.14)	(337.25)	(238.85)	(55.19)	(12.56)	
36-45	816	203	145	38	11	1213
	(817.18)	(207.35)	(146.85)	(35.93)	(7.72)	
46-55	568	143	94	17	4	826
	(556.44)	(141.19)	(99.99)	(23.10)	(5.26)	
56-Over	374	91	58	16	1	540
	(363.80)	(92.31)	(65.37)	(15.10)	(3.44)	
Total	4552	1155	818	189	43	6757

Chi-Square = 11.27
df = 16
Probability = .80 (80 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-100

Comparison of Weather Conditions According to Truck Involvement Frequency by Age of Driver

(1941-1952 Data)

AGE OF DRIVER	WEATHER CONDITIONS Clear Cloudy	Raining	Snowing, Sleet Freezing Rain Hail	Misty Foggy	Total
16-25	643 (612.21)*	102 (108.41)	62 (89.51)	38 (34.86)	845
26-35	1155 (1172.99)	214 (207.71)	175 (171.51)	75 (66.79)	1619
36-45	663 (669.45)	121 (118.54)	108 (97.88)	32 (38.12)	924
46-55	212 (220.26)	37 (39.00)	48 (32.21)	7 (12.54)	304
56-Over	49 (47.09)	8 (8.34)	5 (6.89)	3 (2.68)	65
Total	2722	482	398	155	3757

Chi-Square = 25.60
df = 12
Probability = .02 (less than 2 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-101

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

ESTIMATED INITIAL SPEED	WEATHER CONDITIONS					
	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
0	769	169	142	34	5	1119
	(752.81)*	(190.33)	(137.40)	(31.05)	(7.40)	
1-10	145	35	28	14	0	222
	(149.35)	(37.76)	(27.26)	(6.16)	(1.47)	
11-20	144	53	66	13	2	278
	(187.02)	(47.29)	(34.14)	(7.71)	(1.84)	
21-30	323	97	165	26	6	617
	(415.09)	(104.95)	(75.76)	(17.12)	(4.08)	
31-40	809	208	251	44	14	1326
	(892.07)	(225.54)	(162.82)	(36.80)	(8.77)	
41-50	1201	339	167	33	12	1752
	(1178.66)	(298.00)	(215.13)	(48.62)	(11.59)	
51-60	860	209	32	19	6	1126
	(757.52)	(191.53)	(138.26)	(31.25)	(7.45)	
61-Over	428	73	3	10	1	515
	(346.47)	(87.60)	(63.24)	(14.29)	(3.41)	
Total	4679	1183	854	193	46	6955

Chi-Square = 458.82
df = 28
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-102

Comparison of Weather Conditions According to Truck Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

ESTIMATED INITIAL SPEED	WEATHER CONDITIONS Clear Cloudy	Raining	Snow, Sleet Freezing Rain Hail	Misty Foggy	Total
0	692 (706.30)*	131 (122.66)	113 (106.57)	40 (40.47)	976
1-10	208 (232.30)	39 (40.34)	59 (35.05)	15 (13.31)	321
11-20	332 (353.87)	52 (61.46)	83 (53.40)	22 (20.28)	489
21-30	381 (396.57)	73 (68.87)	65 (59.84)	29 (22.72)	548
31-40	661 (652.02)	121 (113.23)	84 (93.38)	35 (37.36)	901
41-50	477 (419.00)	64 (72.77)	20 (63.22)	18 (24.01)	579
50-Over	59 (49.93)	8 (8.67)	0 (7.53)	2 (2.86)	69
Total	2810	488	424	161	3883

Chi-Square = 95.35
df = 18
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-103

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by Light Conditions

(1941-1952 Data)

	WEATHER CONDITIONS					
LIGHT CONDITIONS	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
Daylight	2933 (2800.58)*	702 (706.16)	441 (512.48)	64 (116.09)	23 (27.67)	4163
Darkness						
Highway Unlighted	1300 (1426.88)	374 (359.78)	339 (261.10)	90 (59.15)	18 (14.10)	2121
Darkness						
Highway Lighted	183 (175.58)	39 (44.27)	27 (32.13)	12 (7.28)	0 (1.73)	261
Dusk-Dawn	240 (252.96)	59 (63.78)	45 (46.29)	27 (10.49)	5 (2.50)	376
Total	4656	1174	852	193	46	6921

Chi-Square = 128.76
df = 12
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-104

Comparison of Weather Conditions According to Truck Involvement Frequency by Light Conditions

(1941-1952 Data)

	WEATHER CONDITIONS					
LIGHT CONDITIONS	**Clear Cloudy**	**Raining**	**Snowing**	**Misty Foggy**	**Sleet Freezing Rain Hail**	**Total**
Daylight	1312	212	194	37	7	1762
	(1276.89)*	(219.97)	(183.00)	(73.02)	(9.13)	
Darkness						
Highway Unlighted	1203	215	173	94	7	1692
	(1226.16)	(211.23)	(175.73)	(70.12)	(8.76)	
Darkness						
Highway Lighted	151	29	11	9	0	200
	(144.94)	(24.97)	(20.77)	(8.29)	(1.04)	
Dusk-Dawn	132	26	23	20	6	207
	(150.01)	(25.84)	(21.50)	(8.58)	(1.07)	
Total	2798	482	401	160	20	3861

Chi-Square = 76.00
df = 12
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-105

Comparison of Weather Conditions According to Passenger Car Involvement Frequency by Roadway Element

(1941-1952 Data)

	WEATHER CONDITIONS					
RODAWAY ELEMENT	Clear Cloudy	Raining	Snowing	Misty Foggy	Sleet Freezing Rain Hail	Total
Straight Level	1798	434	272	83	18	2605
	(1752.92)*	(443.51)	(317.95)	(73.34)	(17.28)	
Straight Up	776	135	119	28	5	1063
	(715.30)	(180.98)	(129.74)	(29.93)	(7.05)	
Straight Down	992	218	219	47	12	1488
	(1001.29)	(253.34)	(181.61)	(41.89)	(9.87)	
Curved Level	186	91	21	12	0	310
	(208.60)	(52.78)	(37.84)	(8.73)	(2.06)	
Curved Up	279	82	71	6	3	441
	(296.75)	(75.08)	(53.82)	(12.42)	(2.93)	
Curved Down	534	195	126	15	7	877
	(590.14)	(149.31)	(107.04)	(24.69)	(5.82)	
Total	4565	1155	828	191	45	6784

Chi-Square = 119.67
df = 20
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-106

Comparison of Weather Conditions According to Truck Involvement Frequency by Roadway Elements

(1941-1952 Data)

ROADWAY ELEMENT	WEATHER CONDITIONS Clear Cloudy	Raining	Snow, Sleet Freezing Rain Hail	Misty Foggy	Total
Straight Level	960 (935.35)*	139 (162.43)	132 (139.42)	59 (52.79)	1290
Straight Up	771 (690.28)	82 (119.87)	67 (102.89)	32 (38.96)	952
Straight Down	544 (580.06)	115 (100.73)	99 (86.46)	42 (32.74)	800
Curved Level	80 (75.41)	11 (13.10)	7 (11.24)	6 (4.26)	104
Curved Up	196 (207.37)	36 (36.01)	45 (30.91)	9 (11.70)	286
Curved Down	213 (275.53)	97 (47.85)	62 (41.07)	8 (15.55)	380
Total	2764	480	412	156	3812

Chi-Square = 138.62
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-107

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by How Vehicle Was Involved

(1941-1952 Data)

	ROADWAY CONDITIONS				
HOW VEHICLE WAS INVOLVED	Dry	Wet	Ice	Snow & Slush	Total
Pedestrian	30	9	2	4	45
	(23.44)*	(8.50)	(9.80)	(3.26)	
Rear End	1416	431	576	186	2609
	(1359.20)	(492.80)	(568.22)	(188.76)	
Stopped, Stopping, Parked.	160	57	105	47	369
	(192.23)	(69.70)	(80.36)	(26.70)	
Medial Strip	224	193	224	75	720
	(375.10)	(136.00)	(156.81)	(52.09)	
Collision W/Obj. Other Than Vehicle	512	221	177	53	963
	(501.70)	(181.90)	(209.74)	(69.67)	
Overturning	555	164	176	45	940
	(489.70)	(177.55)	(204.72)	(68.01)	
Fire Only	58	4	2	0	64
	(33.35)	(12.09)	(13.94)	(4.63)	
Running Off Roadway.....	194	99	78	25	396
	(206.31)	(74.80)	(86.25)	(28.65)	
Sideswiping	329	83	114	44	570
	(296.95)	(107.66)	(124.14)	(41.24)	
Total	3478	1261	1454	483	6676

Chi-Square = 274.37
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-108

Comparison of Roadway Conditions According to Truck Involvement Frequency by How Vehicle Was Involved

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	ROADWAY CONDITIONS Dry	Wet	Ice	Snow & Slush	Total
Pedestrian	11 (9.75)*	3 (2.53)	2 (2.63)	0 (1.08)	16
Rear End	1153 (1130.02)	284 (293.40)	303 (304.91)	114 (125.67)	1854
Stopped, Stopping, Parked	211 (226.74)	49 (58.87)	67 (61.18)	45 (25.22)	372
Medial Strip	59 (134.09)	58 (34.82)	75 (36.18)	28 (14.91)	220
Collision W/Obj. Other Than Vehicle	184 (172.49)	50 (44.79)	38 (46.54)	11 (19.18)	283
Overturning	189 (179.80)	52 (46.68)	45 (48.51)	9 (20.00)	295
Fire Only	183 (124.95)	14 (32.44)	6 (33.71)	2 (13.90)	205
Running Off Roadway	66 (63.39)	19 (16.46)	15 (17.10)	4 (7.05)	104
Sideswiping	201 (215.77)	57 (56.02)	58 (58.22)	38 (24.00)	354
Total	2257	586	609	251	3703

Chi-Square = 238.11
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-109

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Day of Week

(1941-1952 Data)

	ROADWAY CONDITIONS					
DAY OF WEEK	Dry	Wet	Snow	Icy	Slush	Total
Sunday	719 (778.85)*	271 (274.41)	68 (94.94)	409 (317.74)	10 (11.05)	1477
Monday	516 (459.82)	167 (162.01)	42 (56.05)	146 (187.59)	1 (6.52)	872
Tuesday	349 (360.69)	142 (127.08)	49 (43.97)	138 (147.15)	6 (5.12)	684
Wednesday	388 (389.69)	134 (137.30)	63 (47.50)	147 (158.98)	7 (5.53)	739
Thursday	415 (405.51)	128 (142.87)	55 (49.43)	164 (165.43)	7 (5.75)	769
Friday	516 (522.05)	188 (183.93)	62 (63.64)	216 (212.98)	8 (7.41)	990
Saturday	764 (750.38)	262 (264.38)	108 (91.47)	276 (306.13)	13 (10.64)	1423
Total	3667	1292	447	1496	52	6954

Chi-Square = 82.61
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-110

Comparison of Roadway Conditions According to Truck Involvement Frequency by Day of Week

(1941-1952 Data)

	ROADWAY CONDITIONS					
DAY OF WEEK	Dry	Wet	Snow	Icy	Slush	Total
Sunday	273	73	32	126	1	505
	(308.12)*	(79.79)	(31.32)	(82.91)	(2.86)	
Monday	285	99	23	65	0	472
	(287.99)	(74.58)	(29.27)	(77.49)	(2.67)	
Tuesday	323	98	40	73	2	536
	(327.03)	(84.69)	(33.24)	(88.00)	(3.03)	
Wednesday	374	104	45	93	4	620
	(378.29)	(97.96)	(38.45)	(101.79)	(3.51)	
Thursday	387	85	32	101	6	611
	(372.79)	(96.54)	(37.89)	(100.31)	(3.46)	
Friday	391	90	27	102	6	616
	(375.85)	(97.33)	(38.20)	(101.13)	(3.49)	
Saturday	338	65	42	78	3	526
	(320.93)	(83.11)	(32.62)	(86.36)	(2.98)	
Total	2371	614	241	638	22	3886

Chi-Square = 70.37
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-111

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Place Main Line

(1941-1952 Data)

PLACE MAIN LINE	ROADWAY CONDITIONS Dry	Wet	Snow Slush	Ice	Total
Normal	2968 (2978.32)*	1032 (1049.35)	408 (405.28)	1240 (1215.04)	5648
Interchange Area	353 (331.69)	102 (116.86)	36 (45.14)	138 (135.32)	629
Gas Station Area	108 (109.68)	40 (38.65)	28 (14.93)	32 (44.75)	208
Tunnel Approach & Portal	110 (120.76)	54 (42.55)	20 (16.43)	45 (49.26)	229
In Tunnel	97 (78.57)	43 (27.68)	2 (10.69)	7 (32.05)	149
Major & Minor Bridges	31 (47.99)	21 (16.91)	5 (6.53)	34 (19.58)	91
Total	3667	1292	499	1496	6954

Chi-Square = 83.77
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-112

Comparison of Roadway Conditions According to Truck Involvement Frequency by Place Main Line

(1941-1952 Data)

PLACE MAIN LINE	ROADWAY CONDITIONS Dry	Wet	Snow Slush	Ice	Total
Normal	1928 (1913.40)*	484 (495.50)	217 (212.24)	507 (514.87)	3136
Interchange Area	197 (187.31)	39 (48.51)	14 (20.78)	57 (50.40)	307
Gas Station Area	129 (137.28)	46 (35.55)	23 (15.23)	27 (36.94)	225
Tunnel Approach & Portal.	62 (79.31)	22 (20.54)	8 (8.80)	38 (21.34)	130
In Tunnel	39 (36.61)	19 (9.48)	0 (4.06)	2 (9.85)	60
Major & Minor Bridges. . . .	16 (17.09)	4 (4.43)	1 (1.90)	7 (4.60)	28
Total	2371	614	263	638	3886

Chi-Square = 57.57
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-113

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

	ROADWAY CONDITIONS					
NUMBER OF VEHICLES INVOLVED	Dry	Wet	Snow	Icy	Slush	Total
1 Vehicle	1378	532	104	452	20	2486
	(1311.87)*	(460.78)	(159.56)	(535.19)	(18.60)	
2 Vehicles	1938	569	255	741	23	3526
	(1860.67)	(653.54)	(226.30)	(759.09)	(26.39)	
3 or More Vehicles .	351	187	87	303	9	937
	(494.46)	(173.67)	(60.14)	(201.72)	(7.01)	
Total	3667	1288	446	1496	52	6949

Chi-Square = 171.44

df = 8

Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-114

Comparison of Roadway Conditions According to Truck Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

	ROADWAY CONDITIONS					
NUMBER OF VEHICLES INVOLVED	Dry	Wet	Snow	Icy	Slush	Total
1 Vehicle	617	135	18	103	5	878
	(535.44)*	(138.83)	(54.49)	(144.26)	(4.97)	
2 Vehicles	1562	398	184	415	13	2572
	(1568.50)	(406.70)	(159.63)	(422.59)	(14.57)	
3 or More Vehicles .	189	81	39	120	4	433
	(264.06)	(68.47)	(26.87)	(71.14)	(2.45)	
Total	2368	614	241	638	22	3883

Chi-Square = 116.65

df = 8

Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-115

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by State of Registration

(1941-1952 Data)

STATE OF REGISTRATION	ROADWAY CONDITIONS Dry	Wet	Snow	Icy	Slush	Total
In State	1542	534	169	541	20	2806
	(1481.02)*	(521.52)	(180.49)	(601.78)	(21.19)	
Out of State	2093	746	274	936	32	4081
	(2153.98	(758.48)	(262.51)	(875.22)	(30.81)	
Total	3635	1280	443	1477	52	6887

Chi-Square = 16.45
df = 4
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-116

Comparison of Roadway Conditions According to Truck Involvement Frequency by State of Registration

(1941-1952 Data)

STATE OF REGISTRATION	ROADWAY CONDITIONS Dry	Wet	Snow	Icy	Slush	Total
In State	1009	258	118	266	11	1662
	(1016.17)*	(264.16)	(102.27)	(269.82)	(9.57)	
Out of State	1326	349	117	354	11	2157
	(1318.83)	(342.84)	(132.73)	(350.18)	(12.43)	
Total	2335	607	235	620	22	3819

Chi-Square = 5.10
df = 4
Probability = .30 (30 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-117

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Sex of Driver

(1941-1952 Data)

	ROADWAY CONDITIONS					
SEX OF DRIVER	Dry	Wet	Snow	Icy	Slush	Total
Female	558	193	63	193	8	1015
	(534.88)*	(189.23)	(64.86)	(218.32)	(7.72)	
Male	3046	1082	374	1278	44	5824
	(3069.12)	(1085.77)	(372.14)	(1252.68)	(44.28)	
Total	3604	1275	437	1471	52	6839

Chi-Square = 4.78
df = 4
Probability = .50 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-118

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Age of Driver

(1941-1952 Data)

	ROADWAY CONDITIONS					
AGE OF DRIVER	Dry	Wet	Snow	Icy	Slush	Total
16-25	1171	422	120	476	17	2206
	(1167.15)*	(412.67)	(140.71)	(468.49)	(16.98)	
26-35	990	352	151	461	17	1971
	(1042.82)	(368.71)	(125.72)	(418.59)	(15.17)	
26-45	650	219	85	253	6	1213
	(641.78)	(226.91)	(77.37)	(257.61)	(9.33)	
46-55	464	157	45	150	9	825
	(436.49)	(154.33)	(52.62)	(175.21)	(6.35)	
56-Over	300	114	30	95	3	542
	(286.76)	(101.39)	(34.57)	(115.11)	(4.17)	
Total	3575	1264	431	1435	52	6757

Chi-Square = 33.07
df = 16
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-119

Comparison of Roadway Conditions According to Truck Involvement Frequency by Age of Driver

(1941-1952 Data)

AGE OF DRIVER	ROADWAY CONDITIONS				
	Dry	Wet	Snow Slush	Icy	Total
16-25	547 (517.68)*	130 (135.65)	30 (54.58)	137 (136.10)	844
26-35	986 (993.64)	270 (260.37)	107 (104.75)	257 (261.23)	1620
36-45	558 (566.75)	151 (148.51)	72 (59.75)	143 (149.00)	924
46-55	175 (186.45)	45 (48.86)	30 (19.66)	54 (49.02)	304
56-Over	39 (40.48)	8 (10.61)	4 (4.27)	15 (10.64)	66
Total	2305	604	243	606	3758

Chi-Square = 25.88
df = 12
Probability = .02 (less than 2 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-120

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

	ROADWAY CONDITIONS				
ESTIMATED INITIAL SPEED	Dry	Wet	Snow Slush	Icy	Total
0	599	195	91	237	1122
	(591.67)*	(208.46)	(80.51)	(241.38)	
1-10	130	33	19	40	222
	(117.05)	(41.24)	(15.93)	(47.75)	
11-20	92	48	26	113	279
	(147.12)	(51.84)	(20.02)	(60.02)	
21-30	199	91	82	246	618
	(325.89)	(114.82)	(44.34)	(132.95)	
31-40	512	205	149	457	1323
	(697.65)	(245.80)	(94.93)	(284.61)	
41-50	946	389	100	314	1749
	(922.29)	(324.95)	(125.50)	(376.26)	
51-60	784	239	32	72	1127
	(594.31)	(209.39)	(80.88)	(242.46)	
61-70	369	87	0	15	471
	(248.37)	(87.51)	(33.80)	(101.32)	
71-Over	36	5	0	2	43
	(22.66)	(7.98)	(3.08)	(9.25)	
Total	3667	1292	499	1496	6954

Chi-Square = 877.17
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-121

Comparison of Roadway Conditions According to Truck Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

ESTIMATED INITIAL SPEED	ROADWAY CONDITIONS				
	Dry	Wet	Snow Slush	Icy	Total
0	569 (594.89)*	150 (154.05)	77 (65.99)	179 (160.07)	975
1-10	153 (196.46)	48 (50.88)	36 (21.79)	85 (52.87)	322
11-20	265 (300.80)	59 (77.90)	61 (33.37)	108 (80.94)	493
21-30	317 (335.58)	80 (86.90)	39 (37.22)	114 (90.30)	550
31-40	576 (549.13)	174 (142.20)	38 (60.91)	112 (147.76)	900
41-50	435 (352.66)	95 (91.33)	12 (39.12)	36 (94.90)	578
51-Over	56 (41.49)	8 (10.74)	0 (4.60)	4 (11.16)	68
Total	2371	614	263	638	3886

Chi-Square = 207.92
df = 18
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-122

Comparison of Roadway Conditions According to Passenger Car Involvement Frequency by Roadway Element

(1941-1952 Data)

ROADWAY ELEMENT	ROADWAY CONDITIONS Dry	Wet	Snow Slush	Icy	Total
Straight Level	1478 (1378)*	501 (482)	178 (186)	448 (559)	2605
Straight Up	625 (561)	154 (197)	81 (76)	202 (228)	1062
Straight Down	745 (789)	256 (276)	115 (106)	375 (320)	1491
Curved Level	154 (164)	87 (57)	11 (22)	58 (66)	310
Curved Up	212 (233)	71 (82)	30 (31)	128 (95)	441
Curved down	377 (465)	189 (163)	69 (63)	245 (189)	880
Total	3591	1258	484	1456	6789

Chi-Square = 140.08
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-123

Comparison of Road Conditions According to Truck Involvement Frequency by Roadway Element

(1941-1952 Data)

	ROADWAY CONDITIONS				
ROADWAY ELEMENT	Dry	Wet	Snow Slush	Icy	Total
Straight Level	804 (790.37)*	215 (206.41)	94 (87.10)	180 (209.12)	1293
Straight Up	684 (580.71)	138 (151.65)	35 (64.00)	93 (153.64)	950
Straight Down	460 (489.63)	117 (127.87)	72 (53.96)	152 (129.55)	801
Curved Level	70 (63.57)	16 (16.60)	5 (7.01)	13 (16.82)	104
Curved Up	160 (174.82)	47 (45.65)	19 (19.27)	60 (46.25)	286
Curved Down	154 (232.89)	76 (60.82)	32 (25.67)	119 (61.62)	381
Total	2332	609	257	617	3815

Chi-Square = 167.52
df = 15
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-124

Comparison of Road Element According to Passenger Car Involvement Frequency by How Vehicle Was Involved

(1941-1952 Data)

	ROADWAY ELEMENT						
HOW VEHICLE WAS INVOLVED	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Pedestrian	17 (16.46)*	3 (6.74)	14 (9.47)	1 (1.97)	2 (2.80)	6 (5.54)	43
Rear End	1081 (973.44)	481 (398.56)	527 (560.09)	92 (116.77)	157 (165.42)	204 (327.72)	2542
Stopped Stopping Parked	164 (139.38)	54 (57.07)	83 (80.20)	9 (16.72)	18 (23.69)	36 (46.92)	364
Medial Strip ...	238 (269.98)	114 (110.54)	130 (155.34)	38 (32.38)	69 (45.88)	116 (90.89)	705
Collision W/Obj Other Than Vehicle	330 (358.82)	120 (146.91)	218 (206.45)	57 (43.04)	57 (60.97)	155 (120.80)	937
Overturning ...	293 (354.62)	90 (145.19)	235 (204.04)	63 (42.54)	61 (60.26)	184 (119.39)	926
Fire Only	32 (24.13)	9 (9.88)	13 (13.89)	0 (2.90)	2 (4.10)	7 (8.13)	63
Running Off Roadway	130 (148.96)	48 (60.99)	89 (85.71)	17 (17.87)	32 (25.31)	73 (50.15)	389
Sideswipping ...	216 (215.21)	105 (88.12)	130 (123.83)	23 (25.82)	27 (36.57)	61 (72.45)	562
Total	2501	1024	1439	300	425	842	6531

Chi-Square = 264.05
df = 40
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-125

Comparison of Road Element According to Truck Involvement Frequency by How Vehicle Was Involved

(1941-1952 Data)

HOW VEHICLE WAS INVOLVED	ROADWAY ELEMENT						
	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Rear End	602	583	333	39	144	113	1814
	(613.67)*	(459.63)	(378.10)	(49.01)	(136.04)	(177.55)	
Stopped Stopping Parked	147	85	86	11	11	24	364
	(123.14)	(92.23)	(75.87)	(9.84)	(27.30)	(35.63)	
Medial Strip	52	44	44	6	35	35	216
	(73.07)	(54.73)	(45.02)	(5.84)	(16.20)	(21.14)	
Collision W/Obj. Other Than Vehicle	100	39	73	13	19	38	282
	(95.40)	(71.45)	(58.78)	(7.62)	(21.15)	(27.60)	
Overturning	78	25	79	15	22	73	292
	(98.78)	(73.99)	(60.86)	(7.89)	(21.90)	(28.58)	
Fire Only	109	42	31	4	12	6	204
	(69.01)	(51.69)	(42.52)	(5.51)	(15.30)	(19.97)	
Running Off Roadway	29	11	31	4	7	20	102
	(34.51)	(25.84)	(21.26)	(2.76)	(7.65)	(9.98)	
Sideswiping	110	90	79	6	22	46	353
	(119.42)	(89.44)	(73.58)	(9.54)	(26.47)	(34.55)	
Total	1227	919	756	98	272	355	3627

Chi-Square = 338.56
df = 35
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-126

Comparison of Road Element According to Passenger Car Involvement Frequency by Day of Week

(1941-1952 Data)

	ROADWAY ELEMENT						
DAY OF WEEK	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Sunday	142	124	109	17	47	53	492
	(166.57)*	(122.36)	(103.21)	(13.62)	(36.76)	(49.48)	
Monday	162	132	88	10	35	39	466
	(157.77)	(115.89)	(97.75)	(12.90)	(34.81)	(46.87)	
Tuesday	190	119	132	15	27	47	530
	(179.44)	(131.81)	(111.18)	(14.68)	(39.60)	(53.30)	
Wednesday	208	161	111	17	45	63	605
	(204.83)	(150.46)	(126.91)	(16.75)	(45.20)	(60.85)	
Thursday	196	150	125	10	52	73	606
	(205.17)	(150.71)	(127.12)	(16.78)	(45.28)	(60.95)	
Friday	205	144	131	23	45	65	613
	(207.54)	(152.45)	(128.59)	(16.97)	(45.80)	(61.65)	
Saturday	193	122	107	14	35	45	516
	(174.70)	(128.33)	(108.24)	(14.29)	(38.55)	(51.90)	
Total	1296	952	803	106	286	385	3828

Chi-Square = 39.54
df = 30
Probability = .20 (20 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-127

Comparison of Roadway Element According to Truck Involvement Frequency by Day of Week

(1941-1952 Data)

	ROADWAY ELEMENT						
DAY OF WEEK	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Sunday	142 (166.44)*	124 (122.39)	109 (103.13)	17 (13.61)	47 (36.73)	53 (49.70)	492
Monday	162 (157.64)	132 (115.92)	88 (97.68)	10 (12.89)	35 (34.79)	39 (47.04)	466
Tuesday	190 (179.30)	119 (131.84)	132 (111.09)	15 (14.66)	27 (39.57)	47 (53.54)	530
Wednesday	208 (204.67)	161 (150.50)	111 (126.81)	17 (16.74)	45 (45.17)	63 (61.12)	605
Thursday	196 (205.01)	150 (150.75)	125 (127.02)	10 (16.77)	52 (45.24)	73 (61.22)	606
Friday	205 (207.37)	144 (152.49)	131 (128.49)	23 (16.96)	45 (45.76)	65 (61.92)	613
Saturday	193 (175.57)	123 (129.11)	107 (108.79)	14 (14.36)	35 (38.75)	47 (52.43)	519
Total	1296	953	803	106	286	387	3831

Chi-Square = 38.96
df = 30
Probability = .20 (20 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-128

Comparison of Roadway Element According to Passenger Car Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

	ROADWAY ELEMENT						
NUMBER OF VEHICLES	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
1 Vehicle	829	272	580	152	147	444	2424
	(931.40)*	(379.84)	(533.71)	(110.67)	(154.22)	(314.16)	
2 Vehicles	1398	685	664	141	236	324	3448
	(1324.87)	(540.31)	(759.17)	(157.42)	(219.37)	(446.87)	
3 or More Vehicles	382	107	251	17	49	112	918
	(352.73)	(143.85)	(202.12)	(41.91)	(58.41)	(118.98)	
Total	2609	1064	1495	310	432	880	6790

Chi-Square = 247.22
df = 10
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-129

Comparison of Roadway Element According to Truck Involvement Frequency by Number of Vehicles Involved

(1941-1952 Data)

	ROADWAY ELEMENT						
NUMBER OF VEHICLES	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
1 Vehicle	311	113	220	34	65	132	875
	(296.47)*	(217.49)	(183.84)	(24.27)	(65.48)	(87.45)	
2 Vehicles	854	765	463	65	186	191	2524
	(855.20)	(627.37)	(530.29)	(70.00)	(188.87)	(252.27)	
3 or More Vehicles	130	72	120	7	35	59	423
	(143.32)	(105.14)	(88.87)	(11.73)	(31.65)	(42.28)	
Total	1295	950	803	106	286	382	3822

Chi-Square = 170.10
df = 10
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-130

Comparison of Road Element According to Passenger Car Involvement Frequency by State of Registration

(1941-1952 Data)

	ROADWAY ELEMENT						
STATE OF REGISTRATION	**Straight Level**	**Straight Up**	**Straight Down**	**Curved Level**	**Curved Up**	**Curved Down**	**Total**
In State	1097	447	577	118	176	327	2742
	(1053.49)*	(429.46)	(601.24)	(124.56)	(178.70)	(354.56)	
Out of State....	1491	608	900	188	263	544	3994
	(1534.51)	(625.54)	(875.76)	(181.44)	(260.30)	(516.44)	
Total	2588	1055	1477	306	439	871	6736

Chi-Square = 10.15
df = 5
Probability = .10 (10 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-131

Comparison of Road Element According to Truck Involvement Frequency by State of Registration

(1941-1952 Data)

	ROADWAY ELEMENT						
STATE OF REGISTRATION	**Straight Level**	**Straight Up**	**Straight Down**	**Curved Level**	**Curved Up**	**Curved Down**	**Total**
In State	560	407	321	50	123	171	1632
	(550.21)*	(409.30)	(342.90)	(45.53)	(121.40)	(162.59)	
Out of State....	709	537	470	55	157	204	2132
	(718.79)	(534.70)	(448.04)	(59.47)	(158.60)	(212.41)	
Total	1269	944	791	105	280	375	3764

Chi-Square = 4.39
df = 5
Probability = .50 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-132

Comparison of Roadway Element According to Passenger Car Involvement Frequency by Sex of Driver

(1941-1952 Data)

	ROADWAY ELEMENT						
SEX OF DRIVER	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Female	387	130	231	45	56	142	991
	(380.71)*	(154.53)	(217.44)	(44.85)	(64.39)	(129.07)	
Male	2185	914	1238	258	379	730	5704
	(2191.29)	(889.47)	(1251.56)	(258.15)	(370.61)	(742.93)	
Total . . .	2572	1044	1469	303	435	872	6695

Chi-Square = 8.49
df = 5
Probability = .20 (20 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-133

Comparison of Roadway Element According to Passenger Car Involvement Frequency by Age of Driver

(1941-1952 Data)

	ROADWAY ELEMENT						
AGE OF DRIVER	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
16-25	831	357	429	110	145	290	2162
	(828.89)*	(339.41)	(474.77)	(98.09)	(139.29)	(281.53)	
26-35	745	300	437	86	121	237	1926
	(738.42)	(302.36)	(422.95)	(87.39)	(124.09)	(250.80)	
36-45	475	186	254	50	73	149	1187
	(455.08)	(186.34)	(260.66)	(53.86)	(76.48)	(154.57)	
46-55	297	115	192	34	57	111	806
	(309.02)	(126.53)	(177.00)	(36.57)	(51.93)	(104.96)	
56-Over	187	80	140	20	30	74	531
	(203.59)	(83.36)	(116.61)	(24.09)	(34.21)	(69.15)	
Total	2535	1038	1452	300	426	861	6612

Chi-Square = 21.89
df = 20
Probability = .50 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-134

Comparison of Roadway Element According to Truck Involvement Frequency by Age of Driver

(1941-1952 Data)

	ROADWAY ELEMENT						
AGE OF DRIVER	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
16-25	298	199	173	24	68	72	834
	(282.20)*	(208.84)	(174.63)	(23.40)	(61.89)	(83.04)	
26-35	535	437	325	44	112	148	1601
	(541.73)	(400.90)	(335.23)	(44.93)	(118.80)	(159.41)	
36-45	300	227	196	30	67	92	912
	(308.59)	(228.37)	(190.96)	(25.59)	(67.67)	(90.81)	
46-55	104	56	63	5	24	44	296
	(100.16)	(74.12)	(61.98)	(8.31)	(21.96)	(29.47)	
56-Over	17	9	19	1	4	13	63
	(21.32)	(15.78)	(13.19)	(1.77)	(4.67)	(6.27)	
Total	1254	928	776	104	275	369	3706

Chi-Square = 36.75
df = 20
Probability = .02 (less than 2 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE C-135

Comparison of Roadway Element According to Passenger Car Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

	ROADWAY ELEMENT						
ESTIMATED INITIAL SPEED	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
0	493	168	246	35	58	103	1103
	(423.48)*	(172.51)	(242.55)	(50.26)	(71.50)	(142.67)	
1-10	102	21	48	7	14	20	212
	(81.39)	(33.15)	(46.62)	(9.66)	(13.74)	(27.42)	
11-20	110	40	70	9	15	27	271
	(104.06)	(42.39)	(59.60)	(12.35)	(17.57)	(35.06)	
21-30	238	87	149	17	35	80	606
	(232.68)	(94.78)	(133.26)	(27.61)	(39.28)	(78.39)	
31-40	510	199	282	38	94	164	1287
	(494.14)	(201.29)	(283.01)	(58.65)	(83.43)	(166.48)	
41-50	609	272	386	95	114	239	1715
	(658.46)	(268.22)	(377.13)	(78.15)	(111.17)	(221.84)	
51-60	395	194	203	75	66	166	1099
	(421.97)	(171.89)	(241.68)	(50.08)	(71.24)	(142.16)	
61-70	139	75	105	32	43	73	467
	(179.31)	(73.04)	(102.70)	(21.28)	(30.27)	(60.41)	
71-Over	16	8	7	2	2	8	43
	(16.51)	(6.72)	(9.45)	(1.96)	(2.79)	(5.56)	
Total	2612	1064	1496	310	441	880	6803

Chi-Square = 125.34
df = 40
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE C-136

Comparison of Roadway Element According to Truck Involvement Frequency by Estimated Initial Speed

(1941-1952 Data)

ESTIMATED INITIAL SPEED	ROADWAY ELEMENT Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
0	347 (321.54)*	210 (236.20)	212 (199.23)	22 (26.30)	68 (70.96)	90 (94.78)	949
1-10	120 (108.42)	65 (79.64)	61 (67.18)	11 (8.87)	27 (23.93)	36 (31.96)	320
11-20	114 (162.97)	203 (119.72)	64 (100.98)	12 (13.33)	56 (35.97)	32 (48.04)	481
21-30	179 (184.66)	151 (135.64)	114 (114.41)	5 (15.10)	40 (40.75)	56 (54.43)	545
31-40	308 (301.21)	201 (221.26)	194 (186.63)	31 (24.64)	57 (66.47)	98 (88.78)	889
41-50	201 (193.81)	108 (142.36)	138 (120.08)	22 (15.85)	38 (42.77)	65 (57.13)	572
51-Over	27 (23.38)	14 (17.17)	20 (14.49)	3 (1.91)	0 (5.16)	5 (6.89)	69
Total	1296	952	803	106	286	382	3825

Chi-Square = 155.30
df = 30
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

APPENDIX D

HUMAN FACTORS RELATED TO TURNPIKE ACCIDENTS

BEHAVORIAL CONTINGENCY TABLES

Trucks vs. Passenger Cars
How Vehicle Was Involved
Day of Week
Number of Vehicles Involved
State of Registration
Nine Selected States
Sex of Driver
Age of Driver
Estimated Initial Speed
Occupation of Driver

TABLE D-1

Comparison of Passenger Car and Truck Precipitating Factors

PRECIPITATING FACTORS	Passenger Car	Truck	Total
Failure to Cope With Road Conditions	621 (517)*	65 (169)	686
Illegal and Unsafe Actions	434 (505)	237 (166)	671
Vehicle Failures	233 (324)	197 (106)	430
Asleep	310 (310)	102 (102)	412
Routine Skills	316 (275)	49 (90)	365
Misperception	188 (194)	69 (63)	257
Inattention	92 (93)	32 (31)	124
Failure to Avoid Objects in Road	104 (86)	10 (28)	114
Miscellaneous	48 (44)	11 (15)	59
Total	2346	772	3118

Chi-Square = 271.30
df = 8
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-2

Comparison of Precipitating Factors and How Passenger Car Was Involved

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Rear End	Stopped Stopping Parked	Medial Strip	Coll. W/Obj. Other Than Veh.	Over-Turning	Fire Only	Running Off Roadway	Side-swiping	Total
Vehicle Failures . . .	28	1	14	50	65	34	27	4	
	(66)*	(7)	(29)	(46)	(39)	(4)	(19)	(14)	223
Failure to Cope W/Obj. In Road.	4	0	3	82	5	1	2	2	
	(29)	(3)	(13)	(20)	(17)	(2)	(9)	(6)	99
Failure to Cope With Road Conditions.	93	13	139	138	125	0	73	27	
	(180)	(19)	(80)	(124)	(106)	(10)	(53)	(37)	608
Inattention: Asleep.	133	6	35	58	53	0	17	6	
	(91)	(10)	(40)	(63)	(54)	(5)	(27)	(19)	308
Inattention: Attending Other Tasks	37	2	10	14	15	0	11	1	
	(27)	(3)	(12)	(18)	(16)	(1)	(8)	(5)	90
Deficiencies In Routine Driving Skills . . .	28	3	47	76	92	0	42	21	
	(92)	(10)	(41)	(63)	(54)	(5)	(27)	(19)	309
Illegal and Unsafe Actions . .	229	35	30	24	19	1	12	56	
	(120)	(13)	(53)	(83)	(71)	(6)	(35)	(25)	406
Misperception	108	9	14	17	13	0	10	16	
	(56)	(6)	(25)	(38)	(33)	(3)	(16)	(11)	187
Miscellaneous	14	1	6	6	8	0	4	5	
	(13)	(1)	(6)	(9)	(8)	(1)	(4)	(3)	44
Total	674	70	298	465	395	36	198	138	2274

Chi-Square = 1158.85
df = 56
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-3

Comparison of Precipitating Factors and How Truck Was Involved

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Rear End	Stopped Stopping Parked	Medial Strip	Coll. W/Obj. Other Than Veh.	Over-Turning	Fire Only	Running Off Roadway	Side-swiping	Total
Vehicle Failures . . .	17	3	3	26	29	73	22	1	
	(72)*	(15)	(5)	(17)	(19)	(18)	(11)	(15)	174
Failure to Cope W/Obj. In Road.	1	0	1	6	1	0	1	0	
	(4)	(1)	(0)	(1)	(1)	(1)	(1)	(1)	10
Failure to Cope With Road Conditions.	15	7	7	10	15	0	3	4	
	(25)	(5)	(2)	(6)	(7)	(6)	(4)	(5)	61
Inattention: Asleep.	77	2	0	4	9	0	6	1	
	(41)	(8)	(3)	(10)	(11)	(10)	(6)	(9)	99
Inattention: Attending Other Tasks	20	1	2	3	3	0	1	1	
	(13)	(3)	(1)	(3)	(3)	(3)	(2)	(3)	31
Deficiencies In Routine Driving Skills . . .	7	9	1	7	12	0	5	6	
	(20)	(4)	(1)	(5)	(5)	(5)	(3)	(4)	47
Illegal and Unsafe Actions . .	104	35	6	11	8	1	7	42	
	(89)	(18)	(7)	(21)	(24)	(22)	(14)	(19)	214
Misperception	50	3	2	2	1	0	0	8	
	(27)	(6)	(2)	(7)	(7)	(7)	(4)	(6)	66
Miscellaneous	5	1	0	2	1	1	0	0	
	(4)	(1)	(0)	(1)	(1)	(1)	(1)	(1)	10
Total	296	61	22	71	79	75	45	63	712

Chi-Square = 565.80
df = 56
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-4

Comparison of Precipitating Factors and Passenger Car Accidents By Day of Week

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Total
Vehicle Failures . . .	45	35	27	37	21	34	34	233
	(51)*	(32)	(22)	(25)	(25)	(30)	(48)	
Failure to Cope W/Obj. in Road.	23	11	10	9	15	11	25	104
	(23)	(14)	(10)	(11)	(11)	(13)	(22)	
Failure to Cope With Road Conditions	166	69	66	55	55	58	152	621
	(137)	(85)	(58)	(66)	(66)	(80)	(129)	
Inattention: Asleep.	60	52	34	24	35	45	60	310
	(68)	(42)	(29)	(33)	(33)	(40)	(64)	
Inattention: Attending Other Tasks	19	10	4	13	15	12	19	92
	(20)	(13)	(9)	(10)	(10)	(12)	(19)	
Deficiencies In Routine Driving Skills . . .	57	47	29	37	41	37	68	316
	(70)	(43)	(29)	(33)	(34)	(41)	(66)	
Illegal and Unsafe Actions . .	104	58	31	44	43	67	86	433
	(95)	(59)	(40)	(46)	(46)	(56)	(90)	
Misperception	36	33	15	24	19	25	36	188
	(41)	(26)	(18)	(20)	(20)	(24)	(39)	
Miscellaneous	7	6	3	5	7	12	8	48
	(11)	(7)	(4)	(5)	(5)	(6)	(10)	
Total	517	321	219	248	251	301	488	2345

Chi-Square = 78.89
df = 48
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-5

Comparison of Precipitating Factors and Truck Accidents By Day of Week

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Total
Vehicle Failures	19 (25)*	24 (22)	24 (26)	30 (31)	32 (34)	40 (29)	28 (30)	197
Failure to Cope W/Obj. in Road	2 (1)	2 (1)	2 (1)	1 (2)	0 (2)	2 (1)	1 (2)	10
Failure to Cope With Road Conditions	14 (8)	5 (7)	8 (9)	5 (10)	12 (11)	6 (10)	15 (10)	65
Inattention: Asleep	6 (13)	9 (11)	14 (13)	22 (16)	15 (17)	21 (15)	15 (16)	102
Inattention: Attending Other Tasks	4 (4)	1 (4)	9 (4)	4 (5)	6 (5)	4 (5)	4 (5)	32
Deficiencies In Routine Driving Skills	3 (6)	9 (5)	5 (6)	10 (8)	10 (8)	4 (7)	8 (7)	49
Illegal and Unsafe Actions	38 (30)	26 (26)	31 (31)	39 (38)	43 (40)	26 (35)	34 (36)	237
Misperception	11 (9)	10 (8)	8 (9)	12 (11)	7 (12)	11 (10)	10 (11)	69
Miscellaneous	1 (2)	0 (2)	1 (2)	1 (2)	7 (3)	2 (2)	3 (2)	15
Total	98	86	102	124	132	116	118	776

Chi-Square = 68.39
df = 48
Probability = .05 (less than 5 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-6

Comparison of Precipitating Factors and Passenger Car Accidents By Number of Vehicles

(Accident Data 1952-1953)

PRECIPITATING FACTORS	1	2	3 or More	Total
Vehicle Failures	188 (118)*	43 (101)	2 (14)	233
Failure to Cope W/Obj. in Road	87 (53)	17 (45)	0 (6)	104
Failure to Cope With Road Conditions	367 (313)	214 (269)	40 (38)	621
Inattention: Asleep	141 (156)	163 (134)	6 (19)	310
Inattention: Attending Other Tasks	45 (46)	40 (40)	7 (6)	92
Deficiencies In Routine Driving Skills	230 (160)	74 (137)	12 (19)	316
Illegal and Unsafe Actions	58 (219)	309 (188)	67 (27)	434
Misperception	46 (95)	134 (82)	8 (11)	188
Miscellaneous	23 (24)	24 (21)	1 (3)	48
Total	1185	1018	143	2346

Chi-Square = 546.36
df = 16
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-7

Comparison of Precipitating Factors and Truck Accidents By Number of Vehicles

(Accident Data 1952-1953)

PRECIPITATING FACTORS	1	2	3 or More	Total
Vehicle Failures	158	36	3	
	(71)*	(112)	(15)	197
Failure to Cope W/Obj. in Road	7	2	1	
	(4)	(6)	(1)	10
Failure to Cope With Road Conditions	32	24	9	
	(23)	(37)	(5)	65
Inattention: Asleep	18	78	6	
	(37)	(58)	(8)	102
Inattention: Attending Other Tasks	7	24	1	
	(12)	(18)	(2)	32
Deficiencies In Routine Driving Skills	22	22	5	
	(18)	(28)	(4)	49
Illegal and Unsafe Actions	27	183	27	
	(86)	(135)	(18)	237
Misperception	3	61	5	
	(25)	(39)	(5)	69
Miscellaneous	4	7	0	
	(4)	(6)	(1)	11
Total	278	437	57	772

Chi-Square = 303.52
df = 16
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-8

Comparison of Precipitating Factors and Passenger Car Accidents By State of Registration

(Accident Data 1952-1953)

PRECIPITATING FACTORS	In State	Out of State	Total
Vehicle Failures	82 (84)*	151 (149)	233
Failure to Cope W/Obj. in Road	46 (38)	58 (66)	104
Failure to Cope With Road Conditions	191 (225)	430 (396)	621
Inattention: Asleep	124 (112)	186 (198)	310
Inattention: Attending Other Tasks	33 (33)	59 (59)	92
Deficiencies In Routine Driving Skills	112 (114)	204 (202)	316
Illegal and Unsafe Actions	167 (157)	267 (277)	434
Misperception	69 (68)	119 (120)	188
Miscellaneous	25 (17)	23 (31)	48
Total	849	1497	2346

Chi-Square = 19.70
df = 8
Probability = .02 (less than 2 times in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-9

Comparison of Precipitating Factors and Truck Accidents By State of Registration

(Accident Data 1952-1953)

PRECIPITATING FACTORS	In State	Out of State	Total
Vehicle Failures	78 (76)*	119 (121)	197
Failure to Cope W/Obj. in Road	4 (4)	6 (6)	10
Failure to Cope With Road Conditions	33 (26)	32 (39)	65
Inattention: Asleep	32 (40)	70 (62)	102
Inattention: Attending Other Tasks	8 (13)	24 (19)	32
Deficiencies In Routine Driving Skills	20 (19)	29 (30)	49
Illegal and Unsafe Actions	90 (93)	147 (144)	237
Misperception	33 (27)	36 (42)	69
Miscellaneous	5 (4)	6 (7)	11
Total	303	469	772

Chi-Square = 11.91
df = 8
Probability = .50 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-10

Comparison of Types of Accidents Experienced by Drivers From Nine States (Passenger Cars and Trucks)

(1941-1952 Data)

	STATES									
TYPES OF ACCIDENTS	Penna.	N.Y.	N.J.	Ohio	Mich.	Ill.	Ind.	Md.	Va.	Total
Vehicle Failures . . .	163	30	28	52	42	19	9	15	8	366
	(159)*	(31)	(27)	(68)	(31)	(16)	(13)	(12)	(8)	
Failure to Avoid Objects in Road .	51	8	5	19	6	6	2	6	0	103
	(45)	(9)	(8)	(19)	(9)	(5)	(4)	(3)	(2)	
Failure to Cope With Road Conditions	223	61	45	123	45	20	17	19	21	574
	(250)	(49)	(43)	(107)	(48)	(26)	(20)	(19)	(12)	
Inattentiveness	200	31	35	99	41	19	15	15	10	465
	(202)	(40)	(35)	(87)	(39)	(21)	(16)	(15)	(10)	
Deficiencies in Routine Driving Skills	132	30	23	62	24	13	11	10	3	308
	(134)	(26)	(23)	(58)	(26)	(14)	(11)	(10)	(6)	
Illegal and Unsafe Actions	257	46	35	100	46	31	30	17	8	570
	(248)	(49)	(42)	(107)	(48)	(26)	(20)	(19)	(12)	
Misperception	103	19	26	33	17	10	9	5	5	227
	(99)	(19)	(17)	(42)	(19)	(10)	(8)	(8)	(5)	
Miscellaneous	30	3	1	11	3	2	1	1	0	52
	(23)	(4)	(4)	(10)	(4)	(2)	(2)	(2)	(1)	
Total	1159	228	198	499	224	120	94	88	55	2665

Chi-Square = 68.41
df = 56
Probability = Not Significant

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-11

Comparison of Precipitating Factors and Passenger Car Accidents By Sex of Driver

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Female	Male	Total
Vehicle Failures	38 (40)*	194 (192)	232
Failure to Cope W/Obj. in Road	15 (18)	89 (86)	104
Failure to Cope With Road Conditions	117 (107)	503 (513)	620
Inattention: Asleep	24 (53)	284 (255)	308
Inattention: Attending Other Tasks	13 (16)	79 (76)	92
Deficiencies In Routine Driving Skills	98 (54)	214 (258)	312
Illegal and Unsafe Actions	66 (73)	356 (349)	422
Misperception	26 (32)	161 (155)	187
Miscellaneous	3 (8)	45 (40)	48
Total	400	1925	2325

Chi-square = 70.94
df = 8
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-12

Comparison of Precipitating Factors and Passenger Car Accidents By Age of Driver

(Accident Data 1952-1953)

PRECIPITATING FACTORS	16-25	26-35	36-45	46-55	56-over	Total
Vehicle Failures	81	62	39	29	20	
	(89)*	(59)	(38)	(24)	(21)	231
Failure to Cope W/Obj. in Road	30	35	17	14	7	
	(40)	(26)	(17)	(11)	(9)	103
Failure to Cope With Road Conditions	225	177	102	61	51	
	(237)	(158)	(101)	(64)	(56)	616
Inattention: Asleep	179	69	30	14	16	
	(118)	(79)	(50)	(32)	(28)	308
Inattention: Attending Other Tasks	30	28	14	10	10	
	(35)	(24)	(15)	(10)	(8)	92
Deficiencies in Routine Driving Skills	128	61	58	25	39	
	(120)	(80)	(51)	(32)	(28)	311
Illegal and Unsafe Actions	140	102	77	54	43	
	(160)	(106)	(68)	(43)	(38)	416
Misperception	65	43	32	25	20	
	(71)	(47)	(30)	(19)	(17)	185
Miscellaneous	11	14	8	9	5	
	(18)	(12)	(8)	(5)	(4)	47
Total	889	591	377	241	211	2309

Chi-Square = 99.41
df = 32
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-13

Comparison of Precipitating Factors and Truck Accidents By Age of Driver

(Accident Data 1952-1953)

PRECIPITATING FACTORS	16-25	26-35	36-45	46-55	56-over	Total
Vehicle Failures	40	92	47	14	2	
	(43)*	(89)	(45)	(14)	(4)	195
Failure to Cope W/Obj. in Road	2	3	2	2	1	
	(2)	(5)	(2)	(1)	(0)	10
Failure to Cope With Road Conditions	19	26	11	6	1	
	(14)	(29)	(15)	(4)	(1)	63
Inattention: Asleep	21	48	29	3	0	
	(22)	(46)	(24)	(7)	(2)	101
Inattention: Attending Other Tasks	6	18	7	1	0	
	(7)	(15)	(7)	(2)	(1)	32
Deficiencies in Routine Driving Skills	11	20	7	2	3	
	(10)	(20)	(10)	(3)	(1)	43
Illegal and Unsafe Actions	47	98	52	20	6	
	(50)	(101)	(52)	(16)	(4)	223
Misperception	17	30	15	5	1	
	(15)	(31)	(16)	(5)	(1)	68
Miscellaneous	3	4	4	0	0	
	(2)	(5)	(3)	(1)	(0)	11
Total	166	339	174	53	14	746

Chi-Square = 25.04
df = 32
Probability = .50 (50 times in 100 these deviations would occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-14

Comparison of Precipitating Factors and Passenger Car Accidents By Estimated Initial Speed

(Accident Data 1952-1953)

PRECIPITATING FACTORS	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-Over	Total
Vehicle Failures . . .	20 (20)*	4 (6)	7 (7)	15 (15)	34 (36)	67 (65)	55 (58)	29 (24)	2 (3)	233
Failure to Cope W/Obj. in Road	1 (9)	0 (3)	1 (3)	3 (7)	10 (16)	31 (29)	40 (26)	18 (11)	0 (1)	104
Failure to Cope With Road Conditions .	35 (53)	7 (16)	16 (18)	61 (41)	150 (95)	192 (174)	122 (155)	35 (63)	3 (8)	621
Inattention: Asleep	37 (26)	1 (8)	1 (9)	6 (21)	12 (47)	80 (87)	120 (77)	49 (31)	4 (4)	310
Inattention: Attending Other Tasks	4 (8)	3 (2)	3 (3)	5 (6)	9 (14)	24 (26)	34 (23)	8 (9)	2 (1)	92
Deficiencies In Routine Driving Skills	14 (27)	3 (8)	6 (9)	19 (21)	37 (48)	106 (88)	90 (79)	37 (32)	4 (4)	316
Illegal and Unsafe Actions . . .	76 (37)	38 (12)	26 (12)	30 (29)	63 (66)	97 (121)	69 (108)	31 (44)	4 (6)	434
Misperception	5 (16)	5 (5)	5 (5)	15 (12)	38 (29)	48 (53)	44 (47)	24 (19)	4 (2)	188
Miscellaneous	8 (4)	1 (1)	1 (1)	1 (3)	5 (8)	11 (14)	11 (13)	6 (5)	7 (1)	51
Total . . .	200	62	66	155	358	656	585	237	30	2349

Chi-Square = 426.77
df = 64
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-15

Comparison of Precipitating Factors and Truck Accidents By Estimated Initial Speed

(Accident Data 1952-1953)

PRECIPITATING FACTORS	0	1-10	11-20	21-30	31-40	41-50	51-Over	Total
Vehicle Failures	38	11	17	21	51	58	1	
	(33)*	(20)	(14)	(20)	(49)	(54)	(7)	197
Failure to Cope W/Obj. in Road. . .	0	0	0	1	3	5	1	
	(2)	(1)	(1)	(1)	(3)	(3)	(0)	10
Failure to Cope With Road Conditions . .	6	10	10	16	16	6	1	
	(11)	(7)	(5)	(7)	(16)	(18)	(2)	65
Inattention: Asleep . .	12	0	3	9	24	46	8	
	(17)	(10)	(7)	(10)	(26)	(28)	(4)	102
Inattention: Attending Other Tasks	0	2	1	1	9	16	3	
	(5)	(3)	(2)	(3)	(8)	(9)	(1)	32
Deficiencies in Routine Driving Skills	7	12	4	3	12	7	4	
	(8)	(5)	(4)	(5)	(12)	(13)	(2)	49
Illegal and Unsafe Actions	58	36	20	17	58	41	7	
	(40)	(24)	(17)	(24)	(59)	(64)	(9)	237
Misperception	4	4	0	9	19	30	3	
	(12)	(7)	(5)	(7)	(17)	(19)	(3)	69
Miscellaneous	4	4	0	1	1	0	1	
	(2)	(1)	(1)	(1)	(3)	(3)	(0)	11
Total	129	79	55	78	193	209	29	772

Chi-Square = 167.31
df = 48
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE D-16

Comparison of Various Occupational Groups According to Frequency of Casual Behaviors

(1953 Data)

	OCCUPATIONAL GROUP					
CASUAL FACTOR	Transp.	Military	Housewives	Retired	Skilled	Total
Vehicle Failures	102	26	9	3	29	169
	(70)*	(45)	(16)	(5)	(33)	
Failure to Cope With Road Conditions	34	64	23	6	36	163
	(68)	(44)	(15)	(5)	(32)	
Inattentiveness	83	83	12	1	34	213
	(88)	(57)	(20)	(6)	(42)	
Deficiencies in Routine Driving Skills	23	20	30	4	22	99
	(41)	(27)	(9)	(3)	(19)	
Illegal and Unsafe Actions	107	38	11	7	37	200
	(83)	(54)	(19)	(6)	(39)	
Misperception	32	16	3	3	20	74
	(31)	(20)	(7)	(2)	(14)	
Intoxication	8	5	1	2	5	21
	(9)	(6)	(2)	(1)	(4)	
Total	389	252	89	26	183	939

Chi-Square = 161.16
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

APPENDIX E

ENVIRONMENTAL INFLUENCES ON ACCIDENT BEHAVIOR

CONTINGENCY TABLES

Light Conditions
Weather Conditions
Roadway Conditions
Roadway Element

TABLE E-1

Comparison of Precipitating Factors and Passenger Car Accidents by Light Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Vehicle Failures	160	49	6	16	
	(141)*	(71)	(7)	(13)	231
Failure to Cope W/Obj. in Road	40	57	0	7	
	(63)	(32)	(3)	(6)	104
Failure to Cope With Road Conditions	421	153	4	41	
	(377)	(190)	(17)	(35)	619
Inattention: Asleep	139	147	8	15	
	(188)	(95)	(9)	(17)	309
Inattention: Attending Other Tasks	63	21	3	5	
	(56)	(28)	(3)	(5)	92
Deficiencies In Routine Driving Skills	213	83	4	16	
	(192)	(97)	(9)	(18)	316
Illegal and Unsafe Actions. .	289	99	23	20	
	(262)	(132)	(12)	(24)	431
Misperception	80	83	14	9	
	(113)	(57)	(5)	(10)	186
Miscellaneous	17	25	4	2	
	(29)	(15)	(1)	(3)	48
Total	1422	717	66	131	2336

Chi-Square = 196.69
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-2

Comparison of Precipitating Factors and Truck Accidents by Light Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Daylight	Darkness Highway Unlighted	Darkness Highway Lighted	Dusk & Dawn	Total
Vehicle Failures	94	84	8	10	
	(94)*	(81)	(11)	(10)	196
Failure to Cope W/Obj. in Road	3	6	0	1	
	(5)	(3)	(1)	(0)	10
Failure to Cope With Road Conditions	32	29	2	0	
	(30)	(26)	(4)	(3)	63
Inattention: Asleep	32	60	5	5	
	(49)	(42)	(6)	(5)	102
Inattention: Attending Other Tasks	16	14	2	0	
	(15)	(13)	(2)	(2)	32
Deficiencies In Routine Driving Skills	25	14	3	6	
	(23)	(20)	(3)	(2)	48
Illegal and Unsafe Actions.	136	71	18	9	
	(113)	(97)	(13)	(12)	234
Misperception	25	34	4	6	
	(33)	(29)	(4)	(3)	69
Miscellaneous	5	4	1	1	
	(5)	(5)	(1)	(1)	11
Total	368	316	43	38	765

Chi-Square = 53.25
df = 24
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

Figures in parentheses indicate number that would be expected if only chance relationship existed.

TABLE E-3

Comparison of Precipitating Factors and Passenger Car Accidents by Weather Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Clear Cloudy	Raining	Snow—Sleet Freezing Rain Hail	Misty Foggy	Total
Vehicle Failures	204	21	4	3	
	(151)*	(43)	(33)	(5)	232
Failure to Cope W/Obj. In Road	90	9	0	4	
	(67)	(19)	(15)	(2)	103
Failure to Cope With Road Conditions	187	214	214	6	
	(404)	(115)	(89)	(13)	621
Inattention: Asleep	283	16	2	8	
	(201)	(57)	(44)	(7)	309
Inattention: Attending Other Tasks	73	11	5	3	
	(60)	(17)	(13)	(2)	92
Deficiencies In Routine Driving Skills	210	64	38	4	
	(205)	(58)	(45)	(7)	316
Illegal and Unsafe Actions	315	56	51	11	
	(281)	(80)	(62)	(9)	433
Misperception	116	38	23	11	
	(122)	(35)	(27)	(4)	188
Miscellaneous	44	4	0	0	
	(31)	(9)	(7)	(1)	48
Total	1522	433	337	50	2342

Chi-Square = 1123.43
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-4

Comparison of Precipitating Factors and Truck Accidents by Weather Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Clear Cloudy	Raining	Snow—Sleet Freezing Rain Hail	Misty Foggy	Total
Vehicle Failures	183 (157)*	8 (20)	2 (14)	3 (6)	196
Failure to Cope W/Obj. In Road	8 (8)	0 (1)	1 (1)	1 (0)	10
Failure to Cope With Road Conditions	17 (50)	15 (6)	29 (4)	1 (2)	62
Inattention: Asleep	92 (82)	5 (10)	4 (7)	1 (3)	102
Inattention: Attending Other Tasks	27 (26)	5 (3)	0 (2)	0 (1)	32
Deficiencies In Routine Driving Skills	37 (39)	6 (5)	4 (3)	2 (2)	49
Illegal and Unsafe Actions . .	186 (189)	28 (23)	11 (16)	10 (7)	235
Misperception	53 (55)	8 (7)	2 (5)	6 (2)	69
Miscellaneous	10 (9)	1 (1)	0 (1)	0 (0)	11
Total	613	76	53	24	766

Chi-Square = 242.78
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-5

Comparison of Precipitating Factors and Passenger Car Accidents by Roadway Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Dry	Wet	Snow Slush	Ice	Total
Vehicle Failures	198	26	1	7	
	(121)*	(50)	(16)	(45)	232
Failure to Cope W/Obj. In Road	84	18	0	2	
	(54)	(22)	(7)	(20)	104
Failure to Cope With Road Conditions	12	194	95	320	
	(325)	(133)	(42)	(121)	621
Inattention: Asleep	273	33	2	1	
	(162)	(66)	(21)	(60)	309
Inattention: Attending Other Tasks	67	18	3	4	
	(48)	(20)	(6)	(18)	92
Deficiencies In Routine Driving Skills	164	84	19	47	
	(164)	(67)	(21)	(61)	314
Illegal and Unsafe Actions .	279	76	20	58	
	(226)	(93)	(29)	(84)	433
Misperception	106	47	16	18	
	(98)	(40)	(13)	(36)	187
Miscellaneous	42	5	1	0	
	(25)	(10)	(3)	(9)	48
Total	1225	501	157	457	2340

Chi-Square = 882.50
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-6

Comparison of Precipitating Factors and Truck Accidents by Roadway Conditions

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Dry	Wet	Snow Slush	Ice	Total
Vehicle Failures	172	17	2	4	
	(139)*	(30)	(7)	(19)	195
Failure to Cope W/Obj. In Road	8	2	0	0	
	(7)	(2)	(0)	(1)	10
Failure to Cope With Road Conditions	4	12	7	41	
	(46)	(10)	(2)	(6)	64
Inattention: Asleep	87	13	1	1	
	(73)	(16)	(4)	(10)	102
Inattention: Attending Other Tasks	25	5	2	0	
	(23)	(5)	(1)	(3)	32
Deficiencies In Routine Driving Skills	31	11	3	4	
	(35)	(8)	(2)	(5)	49
Illegal and Unsafe Actions	162	39	12	21	
	(166)	(36)	(9)	(22)	234
Misperception	44	19	2	2	
	(48)	(10)	(3)	(6)	67
Miscellaneous	10	1	0	0	
	(8)	(2)	(0)	(1)	11
Total	543	119	29	73	764

Chi-Square = 327.81
df = 24
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-7

Comparison of Precipitating Factors and Passenger Car Accidents by Roadway Element

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Vehicle Failures	78	30	73	7	11	30	
	(73)*	(40)	(49)	(14)	(19)	(34)	229
Failure to Cope W/Obj. in Road. .	49	11	27	4	3	8	
	(33)	(18)	(22)	(6)	(9)	(15)	102
Failure to Cope With Road Conditions .	148	101	134	46	55	130	
	(197)	(106)	(130)	(37)	(52)	(92)	614
Inattention: Asleep	110	78	49	16	28	25	
	(98)	(53)	(65)	(19)	(26)	(46)	306
Inattention: Attending Other Tasks	29	15	19	5	11	13	
	(29)	(16)	(20)	(6)	(8)	(14)	92
Deficiencies In Routine Driving Skills	89	25	58	33	26	81	
	(100)	(54)	(66)	(19)	(26)	(47)	312
Illegal and Unsafe Actions . .	149	86	91	19	42	40	
	(137)	(74)	(91)	(26)	(36)	(64)	427
Misperception	73	49	28	7	16	13	
	(60)	(32)	(39)	(11)	(16)	(28)	186
Miscellaneous	17	6	12	4	3	6	
	(15)	(8)	(10)	(3)	(4)	(7)	48
Total	742	401	491	141	195	346	2316

Chi-Square = 194.86
df = 40
Probability = .001 (less than 1 time in 1000 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

TABLE E-8

Comparison of Precipitating Factors and Truck Accidents by Roadway Element

(Accident Data 1952-1953)

PRECIPITATING FACTORS	Straight Level	Straight Up	Straight Down	Curved Level	Curved Up	Curved Down	Total
Vehicle Failures	67 (69)*	33 (37)	48 (41)	7 (7)	20 (19)	20 (22)	195
Failure to Cope W/Obj. in Road .	6 (4)	0 (2)	3 (2)	0 (0)	1 (1)	0 (1)	10
Failure to Cope With Road Conditions .	16 (23)	5 (12)	14 (13)	2 (2)	9 (6)	18 (7)	64
Inattention: Asleep	38 (36)	37 (20)	12 (21)	2 (3)	6 (10)	7 (11)	102
Inattention: Attending Other Tasks	11 (11)	5 (6)	8 (7)	2 (1)	3 (3)	3 (4)	32
Deficiencies In Routine Driving Skills	19 (17)	7 (9)	4 (10)	1 (2)	3 (5)	14 (5)	48
Illegal and Unsafe Actions . .	87 (82)	36 (44)	54 (49)	7 (8)	28 (22)	20 (26)	232
Misperception	21 (24)	22 (13)	15 (14)	4 (2)	3 (7)	3 (8)	68
Miscellaneous	6 (4)	1 (2)	2 (2)	1 (0)	0 (1)	1 (1)	11
Total	271	146	160	26	73	86	762

Chi-Square = 98.65
df = 40
Probability = .01 (less than 1 time in 100 would these deviations occur by chance alone.)

**Figures in parentheses indicate number that would be expected if only chance relationship existed.*

APPENDIX F

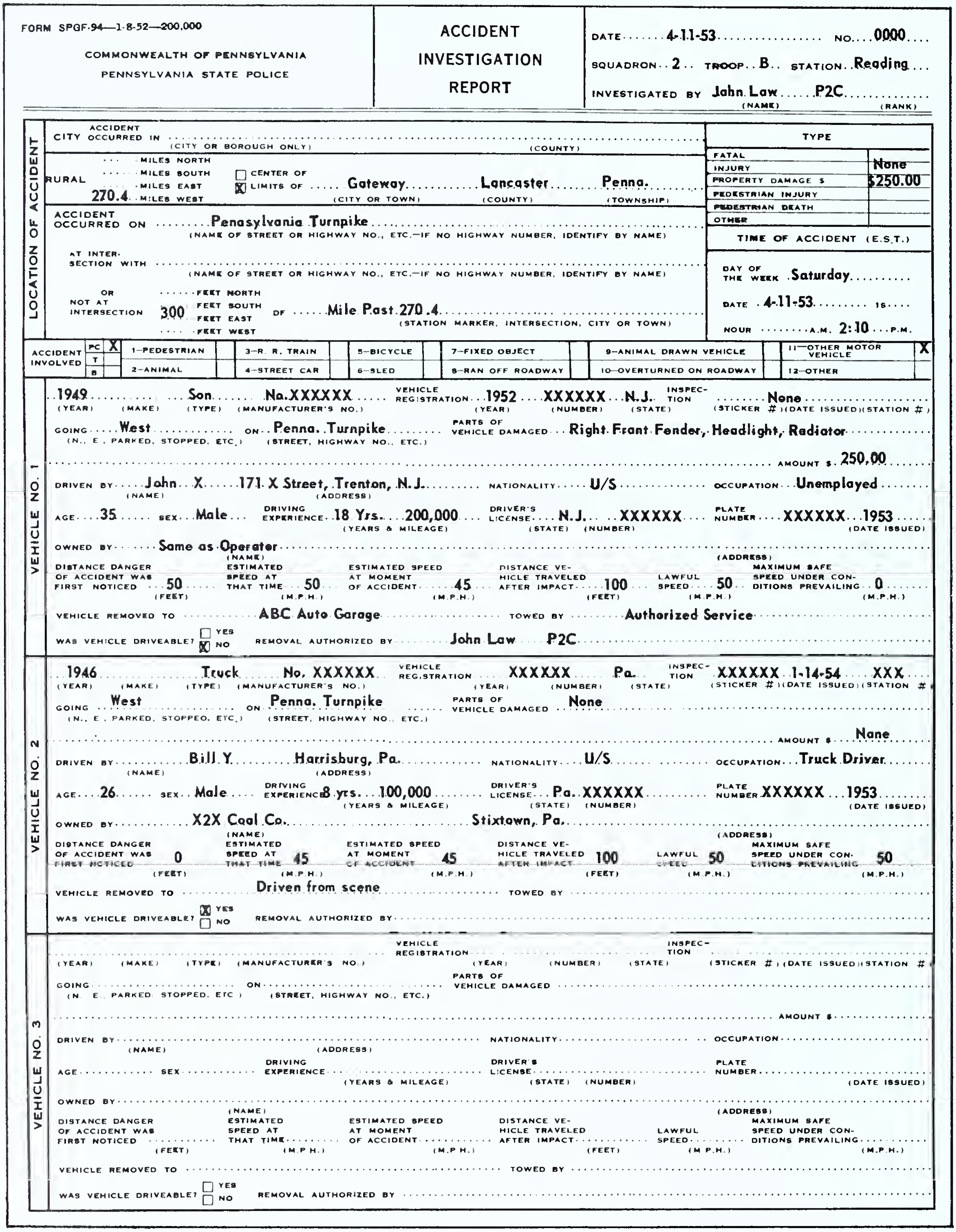
1. SAMPLE ACCIDENT REPORT
2. SAMPLE CODE SHEETS
3. SAMPLE WORK SHEET
4. SAMPLE BUSINESS MACHINE CARDS
5. RADAR SPEED SURVEY

INTRODUCTION

The majority of all data used for this research project was extracted from Pennsylvania State Police Accident Reports. Over 9000 accident reports covering Pennsylvania Turnpike accidents from 1941-1953 were coded into business machine cards. The following sample accident report, code sheet, work sheet, and sample business machine cards will serve to illustrate both the data and the method employed to reduce it to a workable level.

It will be noted that all 80 columns of the standard business machine card were utilized in coding 46 points of information relative to each accident.

The first 21 items (38 columns) on each card were used for information relative to the accident generally. The remaining 25 items contain specific information relative to each vehicle involved in the accident.



FORM SPGF-94—1-8-52—200,000

COMMONWEALTH OF PENNSYLVANIA
PENNSYLVANIA STATE POLICE

ACCIDENT INVESTIGATION REPORT

DATE 4-11-53 NO. 0000
SQUADRON 2 TROOP B STATION Reading
INVESTIGATED BY John Law (NAME) P2C (RANK)

LOCATION OF ACCIDENT

ACCIDENT OCCURRED IN CITY (CITY OR BOROUGH ONLY) (COUNTY)

RURAL: MILES NORTH / MILES SOUTH / MILES EAST / 270.4 MILES WEST
☐ CENTER OF
☒ LIMITS OF Gateway (CITY OR TOWN) Lancaster (COUNTY) Penna. (TOWNSHIP)

ACCIDENT OCCURRED ON Pennsylvania Turnpike (NAME OF STREET OR HIGHWAY NO., ETC.—IF NO HIGHWAY NUMBER, IDENTIFY BY NAME)

AT INTERSECTION WITH (NAME OF STREET OR HIGHWAY NO., ETC.—IF NO HIGHWAY NUMBER, IDENTIFY BY NAME)

OR NOT AT INTERSECTION: FEET NORTH / 300 FEET SOUTH / FEET EAST / FEET WEST OF Mile Post 270.4 (STATION MARKER, INTERSECTION, CITY OR TOWN)

TYPE	
FATAL	
INJURY	None
PROPERTY DAMAGE $	$250.00
PEDESTRIAN INJURY	
PEDESTRIAN DEATH	
OTHER	

TIME OF ACCIDENT (E.S.T.)
DAY OF THE WEEK Saturday
DATE 4-11-53 19
HOUR A.M. 2:10 P.M.

ACCIDENT INVOLVED													
PC	X	1—PEDESTRIAN		3—R. R. TRAIN		5—BICYCLE		7—FIXED OBJECT		9—ANIMAL DRAWN VEHICLE		11—OTHER MOTOR VEHICLE	X
T													
B		2—ANIMAL		4—STREET CAR		6—SLED		8—RAN OFF ROADWAY		10—OVERTURNED ON ROADWAY		12—OTHER	

VEHICLE NO. 1

1949 (YEAR) (MAKE) Son (TYPE) No. XXXXXX (MANUFACTURER'S NO.) VEHICLE REGISTRATION 1952 (YEAR) XXXXXX (NUMBER) N.J. (STATE) INSPECTION None (STICKER #)(DATE ISSUED)(STATION #)
GOING West (N., E., PARKED, STOPPED, ETC.) ON Penna. Turnpike (STREET, HIGHWAY NO., ETC.) PARTS OF VEHICLE DAMAGED Right Front Fender, Headlight, Radiator
AMOUNT $ 250.00
DRIVEN BY John X (NAME) 171 X Street, Trenton, N.J. (ADDRESS) NATIONALITY U/S OCCUPATION Unemployed
AGE 35 SEX Male DRIVING EXPERIENCE 18 Yrs. 200,000 (YEARS & MILEAGE) DRIVER'S LICENSE N.J. (STATE) XXXXXX (NUMBER) PLATE NUMBER XXXXXX 1953 (DATE ISSUED)
OWNED BY Same as Operator (NAME) (ADDRESS)
DISTANCE DANGER OF ACCIDENT WAS FIRST NOTICED 50 (FEET) ESTIMATED SPEED AT THAT TIME 50 (M.P.H.) ESTIMATED SPEED AT MOMENT OF ACCIDENT 45 (M.P.H.) DISTANCE VEHICLE TRAVELED AFTER IMPACT 100 (FEET) LAWFUL SPEED 50 (M.P.H.) MAXIMUM SAFE SPEED UNDER CONDITIONS PREVAILING 0 (M.P.H.)
VEHICLE REMOVED TO ABC Auto Garage TOWED BY Authorized Service
WAS VEHICLE DRIVEABLE? ☐ YES ☒ NO REMOVAL AUTHORIZED BY John Law P2C

VEHICLE NO. 2

1946 (YEAR) (MAKE) Truck (TYPE) No. XXXXXX (MANUFACTURER'S NO.) VEHICLE REGISTRATION (YEAR) XXXXXX (NUMBER) Pa. (STATE) INSPECTION XXXXXX (STICKER #) 1-14-54 (DATE ISSUED) XXX (STATION #)
GOING West (N., E., PARKED, STOPPED, ETC.) ON Penna. Turnpike (STREET, HIGHWAY NO., ETC.) PARTS OF VEHICLE DAMAGED None
AMOUNT $ None
DRIVEN BY Bill Y (NAME) Harrisburg, Pa. (ADDRESS) NATIONALITY U/S OCCUPATION Truck Driver
AGE 26 SEX Male DRIVING EXPERIENCE 8 yrs. 100,000 (YEARS & MILEAGE) DRIVER'S LICENSE Pa. (STATE) XXXXXX (NUMBER) PLATE NUMBER XXXXXX 1953 (DATE ISSUED)
OWNED BY X2X Coal Co. (NAME) Stixtown, Pa. (ADDRESS)
DISTANCE DANGER OF ACCIDENT WAS FIRST NOTICED 0 (FEET) ESTIMATED SPEED AT THAT TIME 45 (M.P.H.) ESTIMATED SPEED AT MOMENT OF ACCIDENT 45 (M.P.H.) DISTANCE VEHICLE TRAVELED AFTER IMPACT 100 (FEET) LAWFUL SPEED 50 (M.P.H.) MAXIMUM SAFE SPEED UNDER CONDITIONS PREVAILING 50 (M.P.H.)
VEHICLE REMOVED TO Driven from scene TOWED BY
WAS VEHICLE DRIVEABLE? ☒ YES ☐ NO REMOVAL AUTHORIZED BY

VEHICLE NO. 3

(YEAR) (MAKE) (TYPE) (MANUFACTURER'S NO.) VEHICLE REGISTRATION (YEAR) (NUMBER) (STATE) INSPECTION (STICKER #)(DATE ISSUED)(STATION #)
GOING (N., E., PARKED, STOPPED, ETC.) ON (STREET, HIGHWAY NO., ETC.) PARTS OF VEHICLE DAMAGED
AMOUNT $
DRIVEN BY (NAME) (ADDRESS) NATIONALITY OCCUPATION
AGE SEX DRIVING EXPERIENCE (YEARS & MILEAGE) DRIVER'S LICENSE (STATE) (NUMBER) PLATE NUMBER (DATE ISSUED)
OWNED BY (NAME) (ADDRESS)
DISTANCE DANGER OF ACCIDENT WAS FIRST NOTICED (FEET) ESTIMATED SPEED AT THAT TIME (M.P.H.) ESTIMATED SPEED AT MOMENT OF ACCIDENT (M.P.H.) DISTANCE VEHICLE TRAVELED AFTER IMPACT (FEET) LAWFUL SPEED (M.P.H.) MAXIMUM SAFE SPEED UNDER CONDITIONS PREVAILING (M.P.H.)
VEHICLE REMOVED TO TOWED BY
WAS VEHICLE DRIVEABLE? ☐ YES ☐ NO REMOVAL AUTHORIZED BY

DAMAGE TO PROPERTY OTHER THAN VEHICLES: None
(NAME OBJECT, SHOW OWNERSHIP, AND STATE NATURE AND AMOUNT OF DAMAGE)

TOTAL NO. OF PERSONS INJURED? AND KILLED

INJURED

1. NAME None AGE SEX ADDRESS
☐ PEDESTRIAN
NATURE OF INJURIES
WAS PERSON KILLED? (YES OR NO)
☐ DRIVER ☐ PASSENGER } OCCUPANT IN VEH. NO. IN (RIGHT FRONT, LEFT REAR, ETC.)
TAKEN TO BY

2. NAME AGE SEX ADDRESS
☐ PEDESTRIAN
NATURE OF INJURIES
WAS PERSON KILLED? (YES OR NO)
☐ DRIVER ☐ PASSENGER } OCCUPANT IN VEH. NO. IN (RIGHT FRONT, LEFT REAR, ETC.)
TAKEN TO BY

3. NAME AGE SEX ADDRESS
☐ PEDESTRIAN
NATURE OF INJURIES
WAS PERSON KILLED? (YES OR NO)
☐ DRIVER ☐ PASSENGER } OCCUPANT IN VEH. NO. IN (RIGHT FRONT, LEFT REAR, ETC.)
TAKEN TO BY

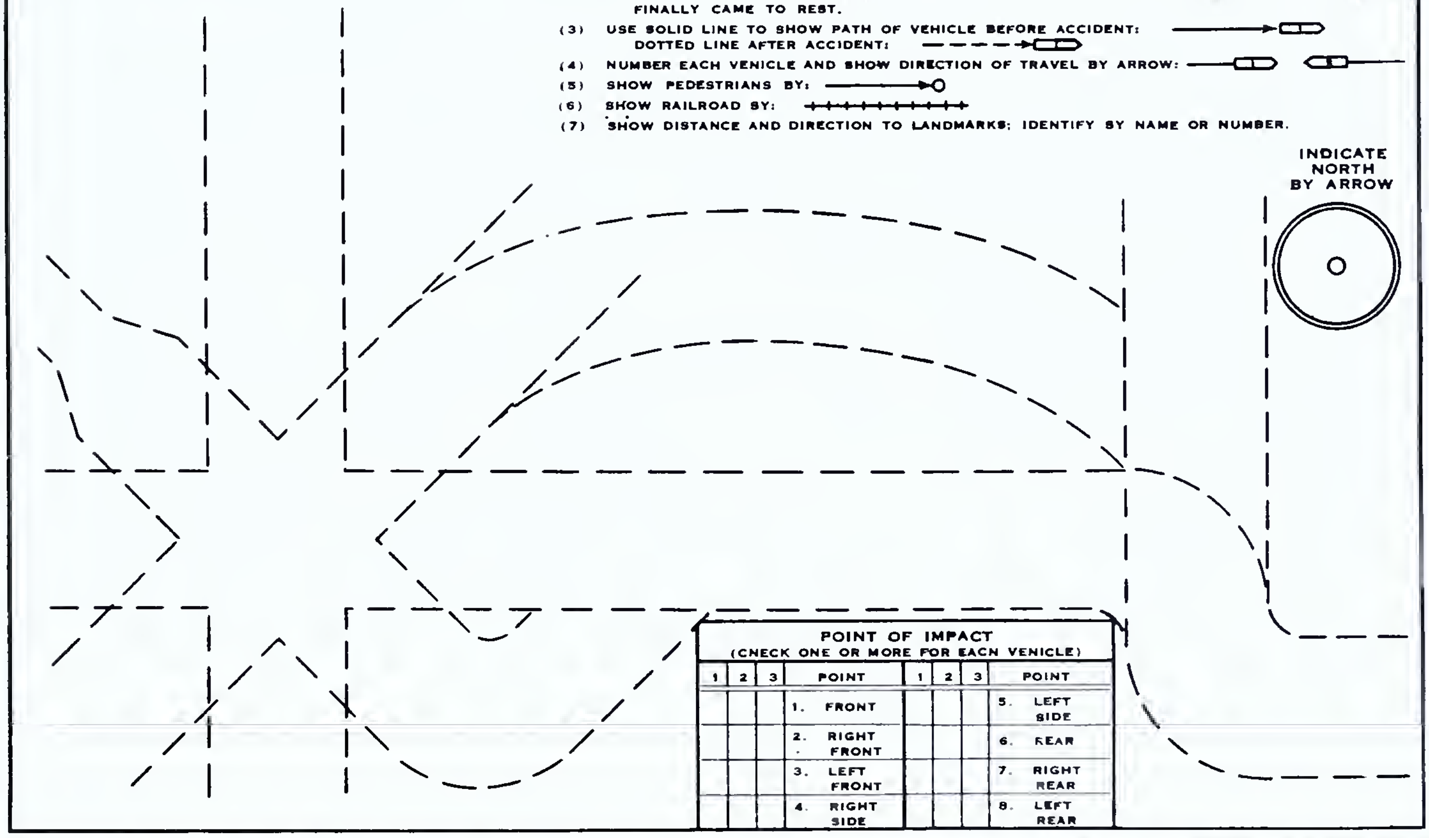
4. NAME AGE SEX ADDRESS
☐ PEDESTRIAN
NATURE OF INJURIES
WAS PERSON KILLED? (YES OR NO)
☐ DRIVER ☐ PASSENGER } OCCUPANT IN VEH. NO. IN (RIGHT FRONT, LEFT REAR, ETC.)
TAKEN TO BY

WITNESSES

WHERE WAS WITNESS? (IN VEH. 2, PED. 50 FT. E, ETC.)
NAME None ADDRESS
NAME ADDRESS
NAME ADDRESS
NAME ADDRESS

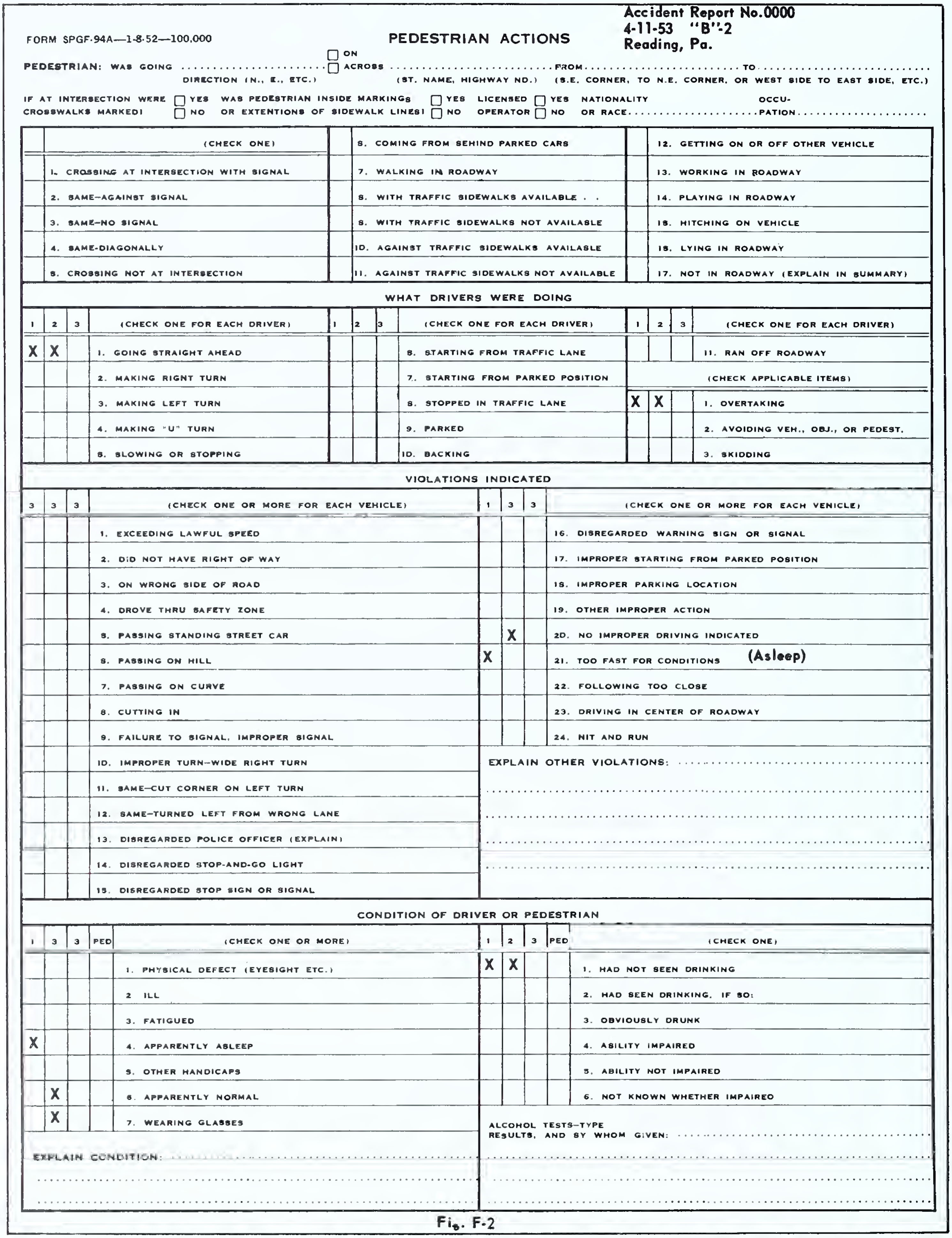
INDICATE ON THIS DIAGRAM WHAT HAPPENED

INSTRUCTIONS:
(1) USE DASH LINES AS GUIDES TO DRAW LINES WHICH WILL SHOW OUTLINE OF ROADWAY AT PLACE OF ACCIDENT.
(2) SHOW WHERE VEHICLES WERE IN ROADWAY WHEN ACCIDENT OCCURRED AND WHERE THEY FINALLY CAME TO REST.
(3) USE SOLID LINE TO SHOW PATH OF VEHICLE BEFORE ACCIDENT: ——→▭
DOTTED LINE AFTER ACCIDENT: - - - →▭
(4) NUMBER EACH VEHICLE AND SHOW DIRECTION OF TRAVEL BY ARROW: ——▭ ▭——
(5) SHOW PEDESTRIANS BY: ——→○
(6) SHOW RAILROAD BY: ┼┼┼┼┼┼┼┼┼┼
(7) SHOW DISTANCE AND DIRECTION TO LANDMARKS; IDENTIFY BY NAME OR NUMBER.



POINT OF IMPACT
(CHECK ONE OR MORE FOR EACH VEHICLE)

1	2	3	POINT	1	2	3	POINT
			1. FRONT				5. LEFT SIDE
			2. RIGHT FRONT				6. REAR
			3. LEFT FRONT				7. RIGHT REAR
			4. RIGHT SIDE				8. LEFT REAR



Accident Report No.0000
4-11-53 "B"-2
Reading, Pa.

FORM SPGF-94A—1-8-52—100,000

PEDESTRIAN ACTIONS

PEDESTRIAN: WAS GOING .... ☐ ON ☐ ACROSS .... FROM .... TO ....
DIRECTION (N., E., ETC.) (ST. NAME, HIGHWAY NO.) (S.E. CORNER, TO N.E. CORNER, OR WEST SIDE TO EAST SIDE, ETC.)

IF AT INTERSECTION WERE CROSSWALKS MARKED? ☐ YES ☐ NO WAS PEDESTRIAN INSIDE MARKINGS OR EXTENTIONS OF SIDEWALK LINES? ☐ YES ☐ NO LICENSED OPERATOR ☐ YES ☐ NO NATIONALITY OR RACE .... OCCUPATION ....

	(CHECK ONE)		6. COMING FROM BEHIND PARKED CARS		12. GETTING ON OR OFF OTHER VEHICLE
	1. CROSSING AT INTERSECTION WITH SIGNAL		7. WALKING IN ROADWAY		13. WORKING IN ROADWAY
	2. SAME—AGAINST SIGNAL		8. WITH TRAFFIC SIDEWALKS AVAILABLE . .		14. PLAYING IN ROADWAY
	3. SAME—NO SIGNAL		9. WITH TRAFFIC SIDEWALKS NOT AVAILABLE		15. HITCHING ON VEHICLE
	4. SAME-DIAGONALLY		10. AGAINST TRAFFIC SIDEWALKS AVAILABLE		16. LYING IN ROADWAY
	5. CROSSING NOT AT INTERSECTION		11. AGAINST TRAFFIC SIDEWALKS NOT AVAILABLE		17. NOT IN ROADWAY (EXPLAIN IN SUMMARY)

WHAT DRIVERS WERE DOING

1	2	3	(CHECK ONE FOR EACH DRIVER)	1	2	3	(CHECK ONE FOR EACH DRIVER)	1	2	3	(CHECK ONE FOR EACH DRIVER)
X	X		1. GOING STRAIGHT AHEAD				6. STARTING FROM TRAFFIC LANE				11. RAN OFF ROADWAY
			2. MAKING RIGHT TURN				7. STARTING FROM PARKED POSITION				(CHECK APPLICABLE ITEMS)
			3. MAKING LEFT TURN				8. STOPPED IN TRAFFIC LANE	X	X		1. OVERTAKING
			4. MAKING "U" TURN				9. PARKED				2. AVOIDING VEH., OBJ., OR PEDEST.
			5. SLOWING OR STOPPING				10. BACKING				3. SKIDDING

VIOLATIONS INDICATED

3	3	3	(CHECK ONE OR MORE FOR EACH VEHICLE)	1	3	3	(CHECK ONE OR MORE FOR EACH VEHICLE)
			1. EXCEEDING LAWFUL SPEED				16. DISREGARDED WARNING SIGN OR SIGNAL
			2. DID NOT HAVE RIGHT OF WAY				17. IMPROPER STARTING FROM PARKED POSITION
			3. ON WRONG SIDE OF ROAD				18. IMPROPER PARKING LOCATION
			4. DROVE THRU SAFETY ZONE				19. OTHER IMPROPER ACTION
			5. PASSING STANDING STREET CAR		X		20. NO IMPROPER DRIVING INDICATED
			6. PASSING ON HILL	X			21. TOO FAST FOR CONDITIONS (Asleep)
			7. PASSING ON CURVE				22. FOLLOWING TOO CLOSE
			8. CUTTING IN				23. DRIVING IN CENTER OF ROADWAY
			9. FAILURE TO SIGNAL, IMPROPER SIGNAL				24. HIT AND RUN
			10. IMPROPER TURN—WIDE RIGHT TURN	EXPLAIN OTHER VIOLATIONS:			
			11. SAME—CUT CORNER ON LEFT TURN	....			
			12. SAME—TURNED LEFT FROM WRONG LANE	....			
			13. DISREGARDED POLICE OFFICER (EXPLAIN)	....			
			14. DISREGARDED STOP-AND-GO LIGHT	....			
			15. DISREGARDED STOP SIGN OR SIGNAL				

CONDITION OF DRIVER OR PEDESTRIAN

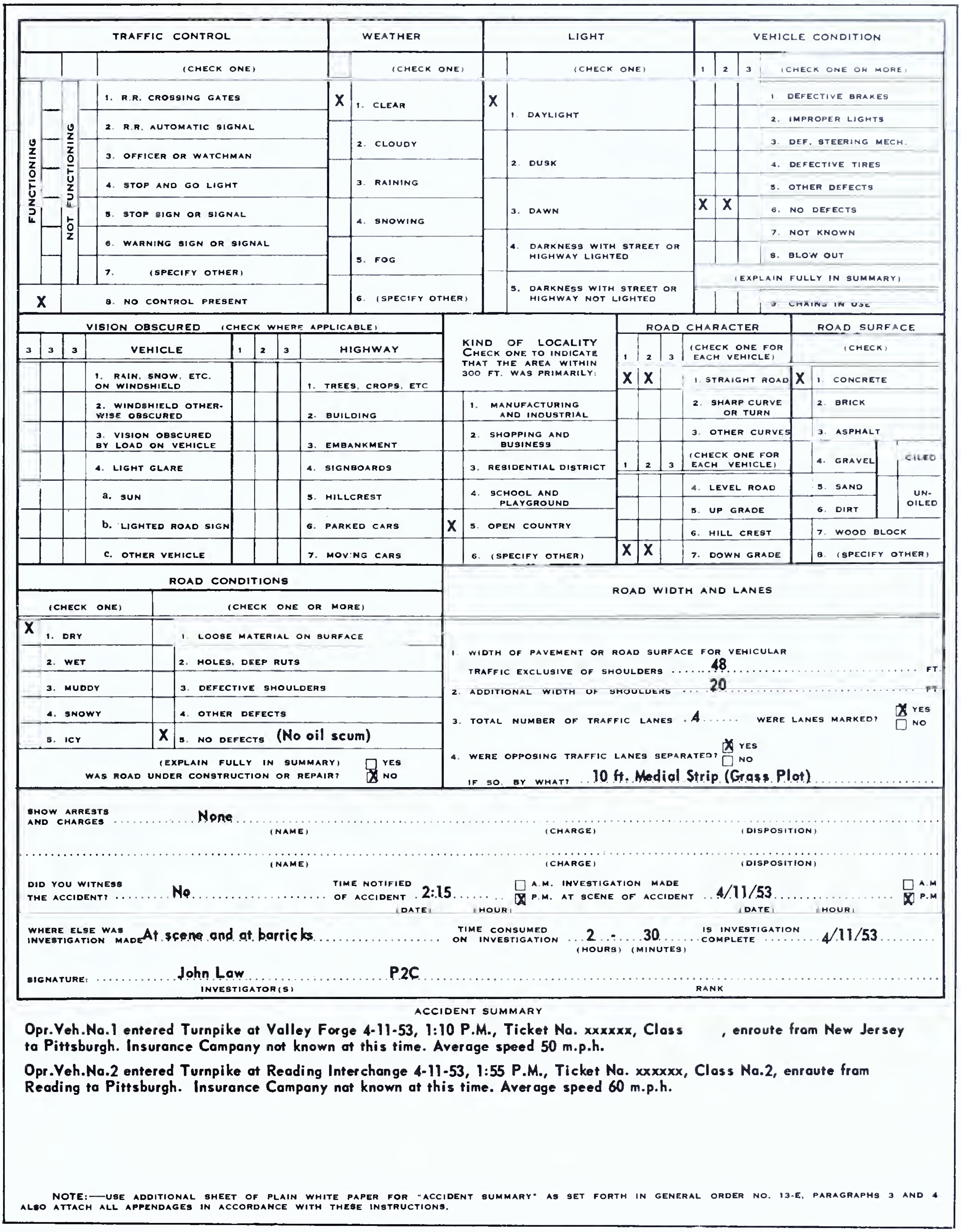
1	3	3	PED	(CHECK ONE OR MORE)	1	2	3	PED	(CHECK ONE)
				1. PHYSICAL DEFECT (EYESIGHT ETC.)	X	X			1. HAD NOT BEEN DRINKING
				2 ILL					2. HAD BEEN DRINKING, IF SO:
				3. FATIGUED					3. OBVIOUSLY DRUNK
X				4. APPARENTLY ASLEEP					4. ABILITY IMPAIRED
				5. OTHER HANDICAPS					5. ABILITY NOT IMPAIRED
	X			6. APPARENTLY NORMAL					6. NOT KNOWN WHETHER IMPAIRED
	X			7. WEARING GLASSES	ALCOHOL TESTS—TYPE RESULTS, AND BY WHOM GIVEN:				

EXPLAIN CONDITION: ....

....

....

Fig. F-2



FUNCTIONING	NOT FUNCTIONING	TRAFFIC CONTROL (CHECK ONE)
		1. R.R. CROSSING GATES
		2. R.R. AUTOMATIC SIGNAL
		3. OFFICER OR WATCHMAN
		4. STOP AND GO LIGHT
		5. STOP SIGN OR SIGNAL
		6. WARNING SIGN OR SIGNAL
		7. (SPECIFY OTHER)
X		8. NO CONTROL PRESENT

	WEATHER (CHECK ONE)
X	1. CLEAR
	2. CLOUDY
	3. RAINING
	4. SNOWING
	5. FOG
	6. (SPECIFY OTHER)

	LIGHT (CHECK ONE)
X	1. DAYLIGHT
	2. DUSK
	3. DAWN
	4. DARKNESS WITH STREET OR HIGHWAY LIGHTED
	5. DARKNESS WITH STREET OR HIGHWAY NOT LIGHTED

1	2	3	VEHICLE CONDITION (CHECK ONE OR MORE)
			1. DEFECTIVE BRAKES
			2. IMPROPER LIGHTS
			3. DEF. STEERING MECH.
			4. DEFECTIVE TIRES
			5. OTHER DEFECTS
X	X		6. NO DEFECTS
			7. NOT KNOWN
			8. BLOW OUT
			(EXPLAIN FULLY IN SUMMARY)
			9. CHAINS IN USE

VISION OBSCURED (CHECK WHERE APPLICABLE)

3	3	3	VEHICLE	1	2	3	HIGHWAY
			1. RAIN, SNOW, ETC. ON WINDSHIELD				1. TREES, CROPS, ETC
			2. WINDSHIELD OTHERWISE OBSCURED				2. BUILDING
			3. VISION OBSCURED BY LOAD ON VEHICLE				3. EMBANKMENT
			4. LIGHT GLARE				4. SIGNBOARDS
			a. SUN				5. HILLCREST
			b. LIGHTED ROAD SIGN				6. PARKED CARS
			c. OTHER VEHICLE				7. MOVING CARS

	KIND OF LOCALITY CHECK ONE TO INDICATE THAT THE AREA WITHIN 300 FT. WAS PRIMARILY:
	1. MANUFACTURING AND INDUSTRIAL
	2. SHOPPING AND BUSINESS
	3. RESIDENTIAL DISTRICT
	4. SCHOOL AND PLAYGROUND
X	5. OPEN COUNTRY
	6. (SPECIFY OTHER)

1	2	3	ROAD CHARACTER (CHECK ONE FOR EACH VEHICLE)
X	X		1. STRAIGHT ROAD
			2. SHARP CURVE OR TURN
			3. OTHER CURVES
1	2	3	(CHECK ONE FOR EACH VEHICLE)
			4. LEVEL ROAD
			5. UP GRADE
			6. HILL CREST
X	X		7. DOWN GRADE

	ROAD SURFACE (CHECK)	
X	1. CONCRETE	
	2. BRICK	
	3. ASPHALT	
	4. GRAVEL	OILED
	5. SAND	UN-OILED
	6. DIRT	
	7. WOOD BLOCK	
	8. (SPECIFY OTHER)	

ROAD CONDITIONS

	(CHECK ONE)		(CHECK ONE OR MORE)
X	1. DRY		1. LOOSE MATERIAL ON SURFACE
	2. WET		2. HOLES, DEEP RUTS
	3. MUDDY		3. DEFECTIVE SHOULDERS
	4. SNOWY		4. OTHER DEFECTS
	5. ICY	X	5. NO DEFECTS (No oil scum)

(EXPLAIN FULLY IN SUMMARY) ☐ YES

WAS ROAD UNDER CONSTRUCTION OR REPAIR? ☒ NO

ROAD WIDTH AND LANES

1. WIDTH OF PAVEMENT OR ROAD SURFACE FOR VEHICULAR TRAFFIC EXCLUSIVE OF SHOULDERS 48 FT.

2. ADDITIONAL WIDTH OF SHOULDERS 20 FT.

3. TOTAL NUMBER OF TRAFFIC LANES 4 WERE LANES MARKED? ☒ YES ☐ NO

4. WERE OPPOSING TRAFFIC LANES SEPARATED? ☒ YES ☐ NO

IF SO, BY WHAT? 10 ft. Medial Strip (Grass Plot)

SHOW ARRESTS AND CHARGES None (NAME) (CHARGE) (DISPOSITION)

(NAME) (CHARGE) (DISPOSITION)

DID YOU WITNESS THE ACCIDENT? No TIME NOTIFIED OF ACCIDENT (DATE) 2:15 (HOUR) ☐ A.M. ☒ P.M. INVESTIGATION MADE AT SCENE OF ACCIDENT 4/11/53 (DATE) (HOUR) ☐ A.M. ☒ P.M.

WHERE ELSE WAS INVESTIGATION MADE At scene and at barricks TIME CONSUMED ON INVESTIGATION 2 (HOURS) - 30 (MINUTES) IS INVESTIGATION COMPLETE 4/11/53

SIGNATURE: John Law INVESTIGATOR(S) P2C RANK

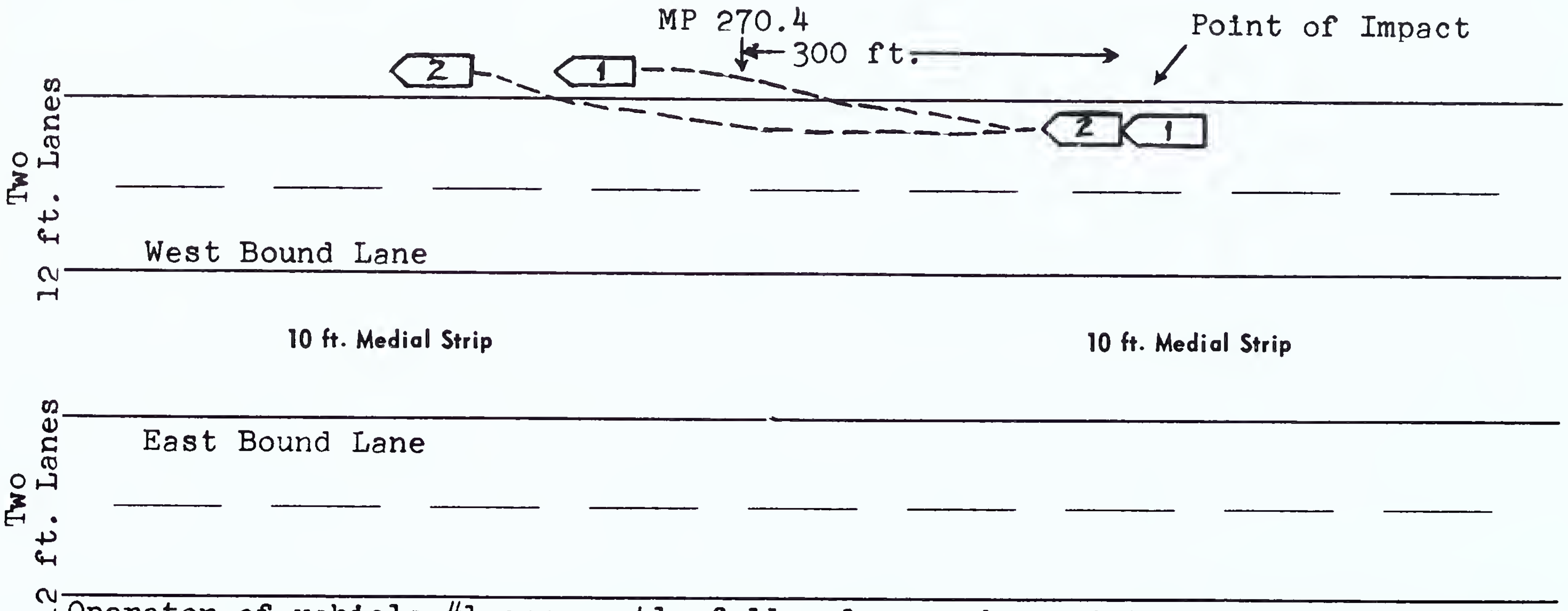
ACCIDENT SUMMARY

Opr.Veh.No.1 entered Turnpike at Valley Forge 4-11-53, 1:10 P.M., Ticket No. xxxxxx, Class , enroute from New Jersey to Pittsburgh. Insurance Company not known at this time. Average speed 50 m.p.h.

Opr.Veh.No.2 entered Turnpike at Reading Interchange 4-11-53, 1:55 P.M., Ticket No. xxxxxx, Class No.2, enroute from Reading to Pittsburgh. Insurance Company not known at this time. Average speed 60 m.p.h.

NOTE:—USE ADDITIONAL SHEET OF PLAIN WHITE PAPER FOR "ACCIDENT SUMMARY" AS SET FORTH IN GENERAL ORDER NO. 13-E, PARAGRAPHS 3 AND 4 ALSO ATTACH ALL APPENDAGES IN ACCORDANCE WITH THESE INSTRUCTIONS.

Date 4/11/53 Rpt No. 0000
Squadron 2 Troop 13 Station Reading
Investigated by John Law (Name) P 2 C (Rank)



Operator of vehicle #1 apparently fell asleep and ran into rear of vehicle #2.

POINT OF IMPACT
(Check one for each vehicle)

1	2	3	Point	1	2	3	Point
			Front				Left Side
X			Right Front				Rear
			Left Front				Right Rear
			Right Side			X	Left Rear

Indicate North by Arrow

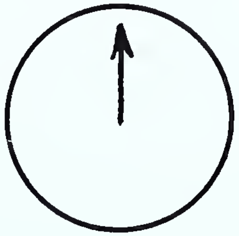


Fig. F-4

Accident Report No. 0000
4-11-53 "B"—2
Reading, Pennsylvania

ACCIDENT SUMMARY

No disinterested witnesses.

Statement of operator of vehicle No. 1:

"I was heading West on the Turnpike at about 50 M.P.H. I got on the Pike at Valley Forge and had been driving along about an hour or an hour and a half before the accident. I don't know what caused me to hit the truck—I was pretty tired. I've driven on the Turnpike about five (5) times before this."

Statement of operator of vehicle No. 2:

"I was traveling West on the Turnpike at about 45 M.P.H. I got on the Turnpike at Reading and had been driving about half an hour before I was hit. I noticed in my rear-view mirror that a car was coming up behind me weaving badly and I got way over near the edge of the road to get out of his way, but he hit me anyway. I've driven on the Turnpike about seven (7) times before."

Statement of Investigating Officer:

"It is this officer's opinion that the accident occurred as stated above and that the operator of vehicle No. 1 fell asleep. Due to the lack of witnesses to this accident, operator of vehicle No. 1 is not being held for disciplinary action."

John Law, P2C

Fig. F-3

ACCIDENT CODE SHEET

Item No.	Item	Code
1	Report Number	Record 4 digit Number
2	Day of Week	1 Sunday
		2 Monday
		3 Tuesday
		4 Wednesday
		5 Thursday
		6 Friday
		7 Saturday
3	Month	01 January
		02 February
		03 March
		04 April
		05 May
		06 June
		07 July
		08 August
		09 September
		10 October
		11 November
		12 December
4	Day	Record the Date—2 Digits
5	Year	Record last two digits of Year
6	Hour	01 Between 12 and 1
		02 " 1 " 2
		03 " 2 " 3
		04 " 3 " 4
		05 " 4 " 5
		06 " 5 " 6
		07 " 6 " 7
		08 " 7 " 8
		09 " 8 " 9
		10 " 9 " 10
		11 " 10 " 11
		12 " 11 " 12
7	AM or PM	1 AM
		2 PM
8	Milepost Location	Record nearest milepost number—(3 and 1 for decimal)
9	Place	01 Main Line, Normal
		02 Same, Minor Bridge
		03 Same, Major Bridge
		04 Same, Tunnel Approach
		05 Same, Tunnel Portal
		06 Same, Within Tunnel
		07 Same, Interchange Area
		08 Same, Gas Station Area
9	Place (Continued)	09 Deceleration Lane, Interchange
		10 Interchange Ramps
		11 At Toll Booths
		12 Acceleration Lane, Interchange
		13 Deceleration Lane, Gas Station
		14 Inside Gas Station
		15 Acceleration Lane, Gas Station
		16 Not on Turnpike
		17 Collision With Bifurcation at Interchange
		18 Collision With Bifurcation at Gas Station
10	Contributing Influence	0 None
		1 Unknown
		2 Unknown Vehicle not Involved in Accident
		3 Known Vehicle not Involved in Accident
11	Types of Vehicles	01 Motorcycle Only
		02 Passenger Car only
		03 Commercial only
		04 Bus only
		05 Motorcycle and Passenger Car
		06 Motorcycle and Commercial
		07 Motorcycle and Bus
		08 Passenger Car and Commercial
		09 Passenger Car and Bus
		10 Commercial and Bus
		11 Motorcycle, Passenger Car and Commercial
		12 Motorcycle, Passenger Car and Bus
		13 Motorcycle, Commercial and Bus
		14 Passenger Car, Commercial and Bus
		15 Motorcycle, Passenger Car, Commercial and Bus
12	Number of Vehicles	Report Number—1 digit
13	Direction of Vehicles	1 Eastbound only
		2 Westbound only
		3 Eastbound and Westbound

Item No.	Item	Code	
13	Direction of Vehicles (Continued)	4	Approaching or Entering Turnpike
		5	Leaving Turnpike
		6	Approaching or Leaving Toll Booth
		7	Eastbound and U Turn
		8	Westbound and U Turn
		9	Eastbound and Westbound and U Turn
		0	North or South
14			
15	Adjusted Milepost Location (3 and 1 for decimal)		
16	Fatalities		Record Total No. of Fatalities—2 Digits
17	Injuries		Record Total No. of Injuries–2 Digits
18	Presence of Witnesses	1	Yes
		2	No
19	Weather Conditions	1	Clear
		2	Cloudy
		3	Misty
		4	Foggy
		5	Raining
		6	Sleeting
		7	Freezing Rain
		8	Hailing
		9	Snowing
		0	Unknown
20	Light Conditions	1	Daylight
		2	Dusk
		3	Dawn
		4	Daylight, Lighted Tunnels
		5	Darkness, Lighted Tunnels
		6	Darkness, Highway Lighted
		7	Darkness, Highway Unlighted
		8	Darkness, Lights Unknown
		9	Unknown
21	Roadway Conditions	01	Dry, Unknown
		02	Dry, Solid
		03	Dry, Soft
		04	Wet, Unknown
21	Roadway Conditions (Continued)	05	Wet, Solid
		06	Wet, Soft
		07	Snowy, Cindered
		08	Snowy, Uncindered
		09	Snowy, Unknown Cinders
		10	Icy, Cindered
		11	Icy, Uncindered
		12	Icy, Unknown Cinders
		13	Slushy
		14	Unknown
22	Year of Manufacture of Vehicle		Record Last Two Digits of Year
23	Type of Vehicle	1	Motorcycle
		2	Passenger Car
		3	Passenger Car and Trailer
		4	Truck
		5	Tractor, Semi-Trailer
		6	Truck Tractor, Full Trailer
		7	Bus
		8	Pedestrian
		9	Tractor
		0	Unknown
24	State of Registration and	01	Alabama
		02	Arizona
		03	Arkansas
30	State of Issue of License of Residence	04	California
		05	Colorado
		06	Connecticut
		07	Delaware
		08	Florida
		09	Georgia
		10	Idaho
		11	Illinois
		12	Indiana
		13	Iowa
		14	Kansas
		15	Kentucky
		16	Louisiana
		17	Maine
		18	Maryland
		19	Massachusetts
		20	Michigan
		21	Minnesota
		22	Mississippi
		23	Missouri
		24	Montana
		25	Nebraska
		26	Nevada
		27	New Hampshire
		28	New Jersey
		29	New Mexico
		30	New York

Item No.	Item	Code
30	State of Issue of License of Residence (Continued)	31 North Carolina
		32 North Dakota
		33 Ohio
		34 Oklahoma
		35 Oregon
		36 Pennsylvania
		37 Rhode Island
		38 South Carolina
		39 South Dakota
		40 Tennessee
		41 Texas
		42 Utah
		43 Vermont
		44 Virginia
		45 Washington
		46 West Virginia
		47 Wisconsin
		48 Wyoming
		49 District of Columbia
		50 Foreign
		51 Unregistered
25	Estimated Damage to Vehicle and Cargo	01 $ 0 to $ 25
		02 25 to 50
		03 50 to 99
		04 100 to 999
		05 1,000 to 1,999
		06 2,000 to 2,999
		07 3,000 to 3,999
		08 4,000 to 4,999
		09 5,000 to 5,999
		10 6,000 to 6,999
		11 7,000 to 7,999
		12 8,000 to 8,999
		13 9,000 to 9,999
		14 10,000 and Over
		15 Unknown
26	Age of Driver or Pedestrian	Record the Age—2 Digits
27	Sex of Driver	1 Female
		2 Male
28	Driving Experience—Years	1 Less than 3 Months
		2 3 Months to 6 Months
		3 6 Months to 1 Year
		4 1 Year to 3 Years
		5 3 Years to 5 Years
		6 5 Years to 10 Years
		7 10 Years and Over
29	Driving Experience—Miles	1 Less than 1,000
		2 1,000 to 4,999
		3 5,000 to 9,999
		4 10,000 to 24,999
29	Driving Experience—Miles (Continued)	5 25,000 to 49,999
		6 50,000 to 99,999
		7 100,000 to 249,999
		8 250,000 to 499,999
		9 500,000 or More
		0 Unknown
30	See 24	
31	Distance Traveled Before Collision	Record as Shown—3 Digits
32	Estimated Initial Speed	Record Speed as Shown—2 Digits
33	Speed at Time of Accident	Record Speed as Shown—2 Digits
34	Maximum Safe Speed Under Prevailing Conditions.	Record Speed as Shown—2 Digits
35	Fatalities	Number of Fatalities in Car—2 Digits
36	Injuries	Number of Injuries in Car—2 Digits
37	Unsafe Action—Secondary	01 Defective Tires
		02 Defective Brakes
		03 Defective Lights
		04 Defective Steering
		05 Other Mechanical Failure
		06 Lost Control
		07 Improper Parking
		08 Improper Start from Parked Position
		09 Failure to Signal
		10 Improper Signal
		11 Disregarding Sign
		12 Failure to Yield ½ Roadway
		13 Failure to Pass Clearly
		14 Cutting in After Passing
		15 Passing on Right
		16 Exceeding Lawful Speed (Maximum)
		17 Exceeding Lawful Speed (Reducing Zone)
		18 Unsafe Speed for Roadway Conditions
		19 Unsafe Speed for Weather Conditions
		20 Unsafe Speed for Vehicle Conditions

Item No.	Item	Code	
37	Unsafe Action—Secondary (Continued)	21	Unsafe Speed for Driver Conditions
		22	Unsafe Speed for Traffic Conditions
		23	Skidding
		24	Cutting Out in Front of Vehicle
		25	Fire Only
		26	Unknown
		27	No Unsafe Action
		28	Crowding
		29	Crowded
38	Unsafe Personal Factors	01	Unpracticed or Unskilled
		02	Illness
		03	Fatigued
		04	Apparently Asleep
		05	Asleep
		06	Defective Eyesight
		07	Defective Hearing
		08	Defective Speech
		09	Defective Arms or Hands
		10	Defective Legs or Feet
		11	Existing Heart Ailment
		12	Existing Other Organic Weakness
		13	Drinking
		14	Intoxicated
		15	Use of Narcotics
		16	Drugged
		17	Unknown
		18	No Unsafe Personal Factor
39	Roadway Element	01	Straight Level
		02	Straight Up-grade
		03	Straight Hillcrest
		04	Straight Down-grade
		05	Straight Valley
		06	Right Curve Level
		07	Right Curve Up-grade
		08	Right Curve Hillcrest
		09	Right Curve Down-grade
		10	Right Curve Valley
		11	Left Curve Level
		12	Left Curve Up-grade
		13	Left Curve Hillcrest
		14	Left Curve Down-grade
		15	Left Curve Valley
		16	Unknown
40	Did Driver Give Statement?	1	Yes
		2	No
41	Number of Trips Over Turnpike	1	One Trip
		2	Two Trips
		3	Three Trips
41	Number of Trips Over Turnpike (Continued)	4	Less than 5
		5	5 to 10 Trips
		6	10 to 20 Trips
		7	More than 20 Trips
		0	Unknown
42	Driven Distance—Miles	1	Less than 10 Miles
		2	10 Miles to 50 Miles
		3	50 Miles to 100 Miles
		4	100 Miles to 150 Miles
		5	150 Miles to 200 Miles
		6	200 Miles to 250 Miles
		7	250 Miles to 300 Miles
		8	300 Miles to 500 Miles
		9	500 Miles or More
		0	Unknown
43	Driven Time—Hours	1	Less than 1 Hour
		2	1 Hour to 2 Hours
		3	2 Hours to 4 Hours
		4	4 Hours to 6 Hours
		5	6 Hours to 8 Hours
		6	8 Hours to 12 Hours
		7	12 Hours to 16 Hours
		8	16 Hours or More
		0	Unknown
44	Unsafe Action—Primary	01	Defective Tires
		02	Defective Brakes
		03	Defective Lights
		04	Defective Steering
		05	Other Mechanical Failure
		06	Lost Control
		07	Improper Parking
		08	Improper Start from Parked Position
		09	Failure to Signal
		10	Improper Signal
		11	Disregarding Sign or Signal
		12	Failure to Yield ½ Roadway
		13	Failure to Pass Clearly
		14	Cutting in After Passing
		15	Passing on Right
		16	Exceeding Lawful Speed (Maximum)
		17	Exceeding Lawful Speed (Reducing Zone)
		18	Unsafe Speed for Roadway Conditions
		19	Unsafe Speed for Weather Conditions
		20	Unsafe Speed for Vehicle Conditions
		21	Unsafe Speed for Driver Condition

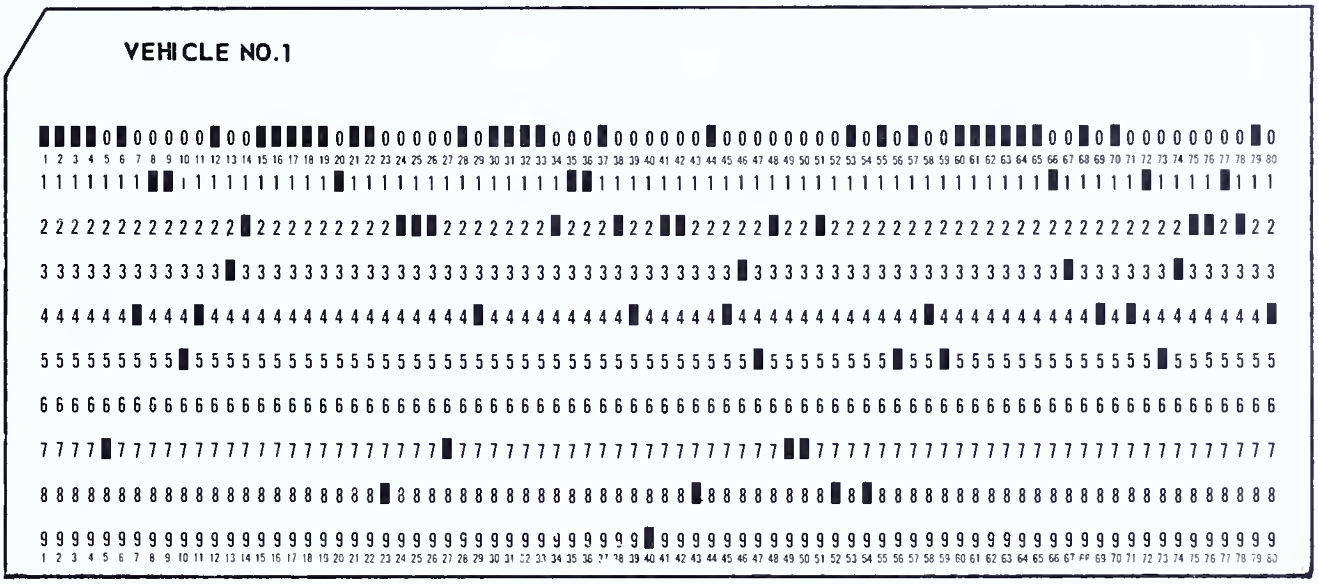
Item No.	Item	Code
44	Unsafe Action—Primary (Continued)	22 Unsafe Speed for Traffic Conditions
		23 Skidding
		24 Cutting Out in Front of Vehicle
		25 Fire Only
		26 Unknown
		27 No Unsafe Action
		28 Crowding
		29 Crowded
45	Type of Accident	1 Collision with Pedestrian
		2 Same, with other Motor Vehicle
		3 Same, with Animal or Bird
		4 Same, with Fixed Object on Roadway
		5 Same, with Other Object on Roadway
		6 Non-Collision, Overturning
		7 Non-Collision, Running Off Roadway
		8 Other Non-Collision Accident
		9 Other Non-Classified Accident
46	How Vehicle or Pedestrian Was Involved	01 Pedestrian Struck by Vehicle
		02 Motor Vehicle Striking Pedestrian
		03 Being Struck in Rear
		04 Striking Vehicle in Rear
		05 Legally Stopped, Stopping or Parked
		06 Striking Legally Parked, Stopped or Stopping Vehicle
		07 Illegally Stopped, Stopping or Parked
		08 Striking an Illegally Parked, Stopping or Stopped Vehicle
46	How Vehicle or Pedestrian Was Involved (Continued)	09 Crossing Medial Strip and Striking Vehicle
		10 Crossing Medial Strip and Being Struck by Vehicle
		11 Striking Vehicle Which Crossed Medial Strip
		12 Being Struck by Vehicle Which Crossed Medial Strip
		13 Collision with Animal or Bird
		14 Collision with Fixed Object on Roadway
		15 Collision with Fixed Object on Shoulder or Medial Strip
		16 Collision with Fixed Object Along Medial Line or Shoulder
		17 Collision with Other Object (Rock, etc.)
		18 Non-Collision, Overturning on Roadway Medial Strip Shoulders
		19 Non-Collision, Running Off Roadway and Overturning
		20 Running Off Roadway Striking Fixed Object
		21 Collision with Motor Vehicle Followed by Fire
		22 Collision with Fixed Object Along Roadway Followed by Fire
		23 Non-Collision Overturning Followed by Fire
		24 Running Off Roadway Striking Fixed Object, Fire
		25 Fire Only
		26 Other
		27 Running Off Roadway
		28 Crossing Medial Strip and Running Off Roadway
		29 Sideswiping by Passing Car
		30 Sideswiping Passing Car

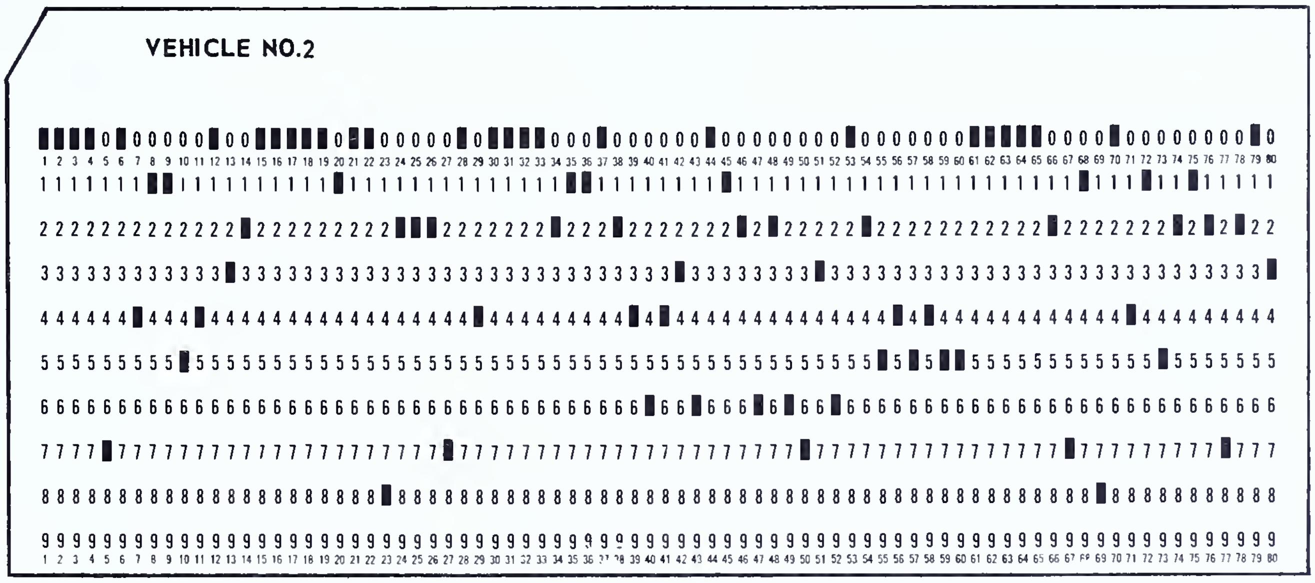
SAMPLE WORKSHEET

ITEM	1	2	3	4	5	6	7	8	9	10	11	12	13	14-15	16	17	18	19	20	21
GENERAL	0000	7	04	11	53	03	2		01	0	08	2	2	2704	00	00	2	1	1	02

ITEM	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Vehicle No.1	49	2	28	04	35	2	7	7	28	080	50	45	00	00	00	13	04	04	1	5	3	2	21	2	04
Vehicle No.2	46	4	36	01	26	2	6	7	36	025	45	45	50	00	00	27	18	04	1	5	2	1	27	2	03

SAMPLE BUSINESS MACHINE CARDS





SAMPLE
RADAR SPEED SURVEY

SER.NO. 146
DAY Tuesday
DATE 4/14/53
TIME 1630-1840
TEST TIME 2Hrs.10 Min.
MILE POST 279.7 W.B.
ZONE 70/50
REMARKS:

VISIBILITY Good (Daylight)
WEATHER Clear-Windy
ROAD COND. Clear-Dry
ROAD ELE. 0.5% Down St. 0.4 Mi.
PRE.RD.ELE. 1.4% Down St. 0.3 Mi.

PASS.CARS 234
TRUCKS 91
BUSSES 0
MISSES 0
TOTAL 325 VEH.PER HR. 153

OBSERVER E.O.G.-D.E.S.

PASSENGER CARS

SPEED	5	10	15	20	25	30	35	40	TOTAL VEHICLES
82	X								1
80	X								1
78									0
76	X								1
74	X X X X								4
72	X X X X X								5
70	X X X X X	X X							7
68	X X X X X	X X X X X							10
66	X X X X X	X X X X X	X X X X X	X X X					18
64	X X X X X	X X X X X	X X X X X	X X X X X					20
62	X X X X X	X X X X X	X X X X X	X X X X X	X X X				23
60	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X				25
58	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X	X X			27
56	X X X X X	X X X X X	X X X X X	X X X X X	X X X X X				25
54	X X X X X	X X X X X	X X X X X	X X X X X					20
52	X X X X X	X X X X X	X X X X X	X					16
50	X X X X X	X X X X X	X X						12
48	X X X X X	X X X X							9
46	X X X X X	X X							7
44	X X								2
42									0
40									0
38	X								1
36									
34									
32									
30									
28									
26									
24									
22									
20									
NO.OF VEHICLES	5	10	15	20	25	30	35	40	

COMMERCIAL VEHICLES

SPEED	5	10	15	20	25	30	35	40	TOTAL VEHICLES
80									
78									
76									
74									
72									
70									
68									
66									
64									
62	T T								2
60	T T								2
58	T T T T								4
56	T T T T T	T T T T T							10
54	T T T T T	T							6
52	T T T T T	T T T T T	T T T T T	T T T T					19
50	T T T T T	T T T T T	T T T T T	T T					17
48	T T T T T	T T T T T	T T T T						14
46	T T T T T	T T							7
44	T T T T								4
42	T T T T								4
40	T								1
38	T								1
36									
34									
32									
30									
28									
26									
24									
22									
20									
NO.OF VEHICLES	5	10	15	20	25	30	35	40	

Litho in U.S.A.

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